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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

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Note.—By an unfortunate oversight the letters employed on p. 583 have not been inserted in Plates **21** and **22**, which illustrate Mr. Worsdell's paper on the Ovule of *Christisonia*.

THE JOURNAL

OF

THE LINNEAN SOCIETY.

A Revision of the Tribe *Naucleeæ* (Nat. Ord. Rubiaceæ).

By G. D. Haviland, M.A., M.B., F.L.S.

[Read 4th February, 1897.]

(Plates 1–4.)

When endeavouring to determine some Bornean plants I found such difficulty with the species of *Nauclea* that it was necessary to go through the whole genus; and eventually I took up the tribe of plants to which it belongs. The causes of confusion have been, partly, that Linnæus founded his *Nauclea orientalis* on more than one species; and partly that A. Richard, when founding new genera, wrote his synonymy at random. Miquel, in his 'Flora Indiæ Bataviæ,' added somewhat to the confusion; but in the 'Ann. Mus. Lugd.-Bat.' vol. iv., he corrected most of the errors that he had made and did much to restore the genus to order. In the 'Flora of British India' Sir Joseph Hooker dealt with the genus *Uncaria*, but the genus *Nauclea* is poorly represented in the regions of that Flora.

Although I worked chiefly at Kew, I found it necessary to visit the Herbaria at the British Museum, at Leiden, and at Paris; at each of these places every possible facility was given me. I am much indebted for help in various matters that I have received at Kew, especially from Mr. Hemsley and from Dr. Stapf.

I have assumed that the object of classification is to simplify knowledge, and that a natural classification is one in which the characters chosen in each group are those most convenient for the group, the groups having been formed by noticing similarity

in very many characters rather than in one or two of supposed importance. Whilst on this view a perfect classification is impossible, the object of classification is most easily defeated by the introduction of a number of different classifications, and most easily attained by using only one. I have also assumed that rules of priority were made to help, and not to hinder; if they were exactly followed, *Uncaria* would be *Ourouparia*, *Sarcocephalus* would be *Nauclea*, *Nauclea* would have to be renamed, and probably *Mitragyna* would be *Mamboga*.

Nomenclature.

I have used the word "Malasia" to denote the islands of the Malayan region, including the Peninsula, the Philippines, and the Moluccas, but excluding the Nicobars and New Guinea. If with Mt. Kinabalu, the highest mountain in the region, as centre, and with an arc of 15 degrees as radius, a circle be described on the surface of the earth, it will cover almost all the region, with the exception of the northern end of Sumatra, but will include, in addition, Cambodia, Cochin China, and Hainan.

I have used the word "Malpina" to denote the Malay Peninsula as far north as the Isthmus of Krah at a latitude of 10°, thus excluding Tenasserim and the Mergui Archipelago. There are objections to the word Malaya: it has been and is often used to denote portions of the Malay Peninsula; but it is at present used in the Kew Herbarium to denote an area which includes New Guinea and Tonquin, but excludes the Malay Peninsula. "Orang Malayu" is the term by which a race of trading and seafaring people know themselves; their headquarters are on the coasts of the sea separating Sumatra on the west from Malpina and Borneo on the east, but they spread along the coasts of other islands almost as far as to New Guinea; and Malaya is on that account not a good word to use in an exact geographical sense.

In his 'Species Plantarum,' ed. i. (1753), Linnæus refers to plants of this Tribe under the name of *Cephalanthus*. He gives two species: *Cephalanthus orientalis*, "foliis oppositis," and *C. occidentalis*, "foliis oppositis ternisque." The latter comes from North America; he had mentioned it in his 'Genera Plantarum,' and the name is still used. The former unfortunately included more than one kind of plant. The first plant to which Linnæus

referred was No. 53 of his 'Flora of Ceylon'; Hermann's drawing, on which this plant depends, is now in the British Museum, and undoubtedly represents *Sarcocephalus cordatus*. The second plant to which he referred is the *Katu Tsiaca* of Rheede's 'Hortus Malabaricus' (1682), iii. 29, t. 33; this plant I have no doubt is *S. missionis*, but it has generally been referred to *Anthocephalus indicus*, and Wight and Arnott, Prod. 392, refer it to *Nauclea purpurea*. The figure of the stigma and the description of the fruit, however, quite exclude *N. purpurea*, whilst the figure of the leaves quite excludes *Anthocephalus indicus*; the figure of the calyx-lobes shows them to be persistent and obtuse as in *Sarcocephalus missionis*. Specimens of *S. missionis* from Wight's herbarium are labelled *Nauclea purpurea*.

In the 'Species Plantarum,' ed. 2, *Cephalanthus occidentalis* is left under *Tetrandria*; but *Cephalanthus orientalis* is called *Nauclea orientalis* and classed under *Pentandria*; the same references to the 'Flora Zeylanica' and the 'Hortus Malabaricus' are given, and a reference to a third plant, the *Bancalus* of Rumph. Amb. (1750), iii. 84, is added. This *Bancalus* is also probably a *Sarcocephalus*, judging by the description of the fruit; it is peculiar in having some of the peduncles axillary and some terminal: the only specimen which I have seen with this peculiarity is from the Philippines (Vidal, n. 797), where the name Bancal is in use for species of *Nauclea* and *Sarcocephalus*. It is a *Sarcocephalus*; I have referred it to *S. Junghuhnii*, but it will possibly prove to be distinct. The young fruit closely resemble those in the figure, but the leaves are much broader.

Thus it would seem that Linnæus founded his *Nauclea orientalis* on two species of *Sarcocephalus*: the first is *Sarcocephalus cordatus* and the second *Sarcocephalus missionis*; and in the 2nd edition of the 'Species Plantarum' he included a third species which was also almost certainly a species of *Sarcocephalus*. He, however, says in Sp. Pl. ed. 1, "Capsulas habet binas monospermas;" and Smith in 'Rees's Cyclopædia' states that the name *Nauclea* possibly comes from "*Naus*" a ship and "*Kleio*" to enclose, in reference to the hull-shaped half-capsule, but the writer admits this to be a mere guess. For a time all the Asiatic species of the Tribe were included in the genus *Nauclea*; so that when *Cephalanthus occidentalis* was found in Asia, it was renamed *Nauclea tetrandra*

by Roxburgh. At first many specimens of different species were named *Nauclea orientalis*; there is a specimen of *Mitragyna parvifolia* so named in the Banksian Herbarium, and referred to by Gaertner in 1788, 'De Fructibus,' i. p. 151. Mr. Daydon Jackson is of opinion that the name is probably not Linnæus's. The only other specimen in the Herbarium labelled *Nauclea* is one of *Adina globiflora*; and Mr. Jackson thinks the writing in this case is undoubtedly that of Linnæus. The genera *Uncaria*, *Sarcocephalus*, *Adina*, and *Mitragyna* have since been formed, and plants have been removed from the original genus *Nauclea*. It was not until 1888 that Dr. Trimen (Journ. Linn. Soc. xxiv. p. 136) pointed out that No. 53 of Linnæus's Flor. Zeyl. was *Sarcocephalus cordatus*, Miq.

Aublet in 1775, 'Hist. Plant. de la Guiane françoise,' i. p. 177, described and figured *Ourouparia guianensis*, and pointed out its relationship to the "daun gutta gambir" of Rumphius. In 1789 Schreber, in his edition of Gen. Pl., acknowledged Aublet's genus but renamed it, substituting *Uncaria* for *Ourouparia*; and that name has come into general use, though Baillon, K. Schumann, and others have recently returned to *Ourouparia*, sometimes writing it *Uruparia*. I shall regard *Uncaria* and *Ourouparia* as absolutely equivalent. In the Linnean Society's 'Transactions' for 1808 Dr. Hunter, under the name *Nauclea*, described three species of *Uncaria*, and made no reference to Aublet's description of the American *Uncaria*; Roxburgh was the first in Asia to distinguish *Uncaria* from *Nauclea*. Blume, however, reunited them, and DeCandolle, though he separated them again, did so with hesitation.

Salisbury in 1807, Parad. Londin. p. 115, founded the genus *Adina* on the Chinese species *Adina globiflora*; but it was long before the value of the genus was recognized. DeCandolle makes two species of *Adina* out of *Adina globiflora*, but other species he leaves in the genus *Nauclea*. Smith, in 'Rees's Cyclopædia,' and Baillon, in 'Adansonia,' reduce the genus back to *Nauclea*; Bentham, in the 'Flora of Hongkong,' points out an Indian species of *Adina*; and others are indicated in Bentham and Hooker's 'Genera Plantarum.' In the 'Flora of British India' Sir Joseph Hooker placed two species in *Adina* which, though in some respects intermediate between *Adina* and *Nauclea*, seem to me best classed with the latter genus.

A specimen from Africa of *Nauclea sambucina*, Winterbottom

(1803), was labelled *Sarcocephalus esculentus* by Afzelius perhaps as early as 1798; but the name *Sarcocephalus* was not published till 1818 in Tuckey's 'Congo' (Append. by R. Br. p. 467), nor was there any description of it till 1824, when Sabine described it in Trans. Hort. Soc. v. p. 422. The nearest Asiatic plant to this *Sarcocephalus esculentus* is the No. 53 of Linnæus's 'Flora Zeylanica,' the first type of his *Nauclea orientalis*, the *Nauclea cordata* of Roxburgh. It was Korthals, in 1839, 'Obs. de Naucl. Ind.', who first separated this *Nauclea cordata* on account of the ovaries being combined, and put it into a genus *Platanocarpum*, the relationship of which to *Sarcocephalus* he pointed out, at the same time he founded the genus *Mitragyna*. It was he, therefore, who was responsible for the removal from the genus *Nauclea* of most, if not all, of its types. Miquel in 1856 united *Platanocarpum* to *Sarcocephalus*.

It was in 1834 that *Anthocephalus* was separated from *Nauclea* by A. Richard, Mém. Soc. Hist. Nat. v. p. 236; and Korthals accepted his genus. There can be no doubt as to the species which Richard had before him when describing *Anthocephalus indicus*. Unfortunately his synonymy was most erratic: he says (p. 327) that *Anthocephalus indicus*=*Cephalanthus chinensis*, Lam.,=*Nauclea purpurea*, Roxb.; he even went so far as to say that the plant he examined was an authentic specimen of *Cephalanthus chinensis*, Lam.; but a comparison of his description with that of Lamarck's will show at once that the plants are wholly different.

A specimen of *Breonia* in the Paris Herbarium still has attached to its sheet sections of the fruiting-heads of *Anthocephalus indicus*, a label on the left "*Cephalanthus chinensis*, Lmk., fide herb.," and a label on the right "*Nauclea purpurea*, Bomb., Pl. Corom. i. 41, tab. 54; Flor. Ind. ii. p. 123; DC. Prod. iv. 346. *Cephalanthus chinensis*, Lamk. Dict. i. 678. Inde ? Ile de France ? Herb. de Commerson."

Richard's description of his plants is good; but his synonymy seems to have been written at random and regardless of consequences. It has been copied from author to author, causing the utmost confusion. Walpers, Repert. ii. p. 491, has hybridized the names *Anthocephalus indicus* and *Cephalanthus chinensis* and produced *Anthocephalus chinensis*, a name which is also quoted by Hasskarl. Korthals described *Anthocephalus indicus* again as *A. morindæfolius*, believing it to be identical with Blume's

Nauclea morindæfolia, which it is not, as I shall show later on. Miquel describes *Anthocephalus indicus* three times, as *A. morindæfolius* for Korthals, as *A. Cadamba* for Roxburgh, and as *A. indicus* for Richard; though the last description has been converted into that of *Nauclea purpurea* on the strength of Richard's erroneous synonymy. The nearest plant to *Anthocephalus indicus* is *Nauclea macrophylla*, Roxb., which has probably not been examined since the days of Roxburgh; it is not a *Nauclea* as the genus is now known: either it must form a genus by itself, or the genus *Anthocephalus* must be modified to receive it. I propose to modify the genus *Anthocephalus*.

Richard founded the genera *Cephalidium* and *Breonia* on Madagascar plants at the same time as he founded the genus *Anthocephalus*; owing to his erroneous synonymy, Endlicher, Gen. Pl. 1393, reduced *Cephalidium* to *Anthocephalus*; but it was a Madagascar plant, and the type specimen, still in the Paris Herbarium, shows that it was a *Breonia* in fruit from which the bracts had fallen. Baillon wished to reduce *Breonia* to *Sarcocephalus*, which it simulates in having the ovaries united; but these genera are quite distinct in stigma, in stipules, and in peduncles.

Although *Mitragyna* is, with the exception of *Uncaria*, the most distinct genus of the Tribe, it was not till 1839 that Korthals, 'Obs. de Naucl. Ind.', distinguished it from *Nauclea*. In Ver. Nat. Gesch., 1840, he substituted the name *Stephegyne* for that of *Mitragyna*: he gives *Mitragyne*, Korth., as a synonym, evidently by error for *Mitragyna*; the plate bears the name *Mitragyna*. Though *Mitragyna* is the older name, Korthals evidently wished it changed to *Stephegyne*. *Mitragyne* had been suggested as a better name than *Mitrasacme* by R. Brown, Prod. 452, in 1810. Blanco founded the genus *Mamboga* on a Philippine species of *Mitragyna* in 1837. Thus *Mamboga* is, according to the rules of priority, preferable to *Mitragyna*; but the genus was badly defined, and has never been accepted.

Characters.

The most constant character of the Tribe is the crowding of the flowers into heads; this must introduce conditions different from those observed in most flowers, both in respect of protection from rain and insects and of danger from overcrowding. In

respect of protection from rain and insects, it will be well to remember that the presence of interfloral hairs and setæ is of use, that the union of the ovaries of the different flowers in a solid mass may also prevent rain and insects from getting in between them; and when the flowers are densely crowded, only the tips of the calyx-lobes are of use in giving the corolla-buds protection. In respect of the danger due to mutual compression from overcrowding, it will be well to remember that the overcrowding may be lessened by diminishing either the size or the number of the flowers and ovaries, or by increasing the size of the receptacle or the length of the flower-pedicels. Another very constant character is the shortness of the filaments and the length of the styles, so that the anthers are not in a position corresponding to the stigmas. In bud the style is short and the anthers surround the capitate stigma, bending over it at the top; the anthers burst before the flower opens, and the style when it elongates carries up the stigma tipped with pollen to a height of nearly twice the length of the corolla-tube, and sometimes more; the pollen thus carried on the stigma is in the very best position to be effective in the fertilization of other flowers when dusted on to insects. The stigma probably ripens later. The most variable character of the Tribe is that of the superior portion of the calyx and the calyx-lobes—the majority of species could be determined by the character of the calyx-lobes alone.

When the flowers are very densely crowded, the calyx-lobes may become filamentous in the lower part between the flowers, but so thickened at the tips as to press against one another, and thus form a complete outer shell to the flower-heads in bud: when the time comes for the corollas to open, they cannot separate the crowded tips of the calyx-lobes; for a time the calyx-lobes lengthen with the corolla, but eventually they break off at the thinnest part, generally near the base. In such flowers the anthers are usually within the corolla-tube, whilst in the other species the anthers are seated in the mouth of the corolla-tube and project beyond it. Generally the connective is apiculate at the tip; and especially is this so when the corolla in bud is pressed upon by the tips of the calyx-lobes. At the base the anther-cells generally diverge and are sometimes setose. The filaments are always shorter than the anthers.

The corolla-lobes are always imbricate excepting in the genus

Mitragyna, in which they are truly valvate. In some species of *Adina* the overlapping of the lobes is very slight indeed, but the lobes are not valvate as they are in *Mitragyna*. In all species of *Uncaria* the lobes are strongly imbricate; and it must have been due originally to some clerical error that they are called valvate in Bentham and Hooker's 'Genera Plantarum.'

The style is long, from 1½ to 3 times the length of the corolla-tube. The stigma is always capitate, though it varies in shape, and may be clavate, subglobose, spindle-shaped, or mitrate, and provides valuable characters for generic grouping. When clavate or subglobose, the papillose area is on the top: when spindle-shaped, there are two distinct papillose areas which are almost in contact on the lower half of the spindle and end below abruptly; on the upper half of the spindle the two papillose areas rapidly diverge and do not reach nearly to the top; in dried specimens the top of the spindle-shaped stigma shrivels and becomes acute: when mitrate, the stigma is cylindrical with overhanging lower margin.

The ovary and the seeds give characters which are of great value for generic grouping. The ovaries are always two-celled; the placentas may be long and linear, attached to the middle of the axis, or they may be pendulous from its upper part; the ovules, excepting when solitary, are more or less flattened and directed either upwards or downwards, overlapping one another. When the placentas are linear with central attachment, the ovules are very numerous; but when the placentas are pendulous, the ovules are fewer. The seeds are almost always flattened, and frequently the testa is produced to a great length at either end. When the calyx-tubes of the different flowers are united or indehiscent, a somewhat pulpy fruit is generally formed. When the ovules are solitary the fruits are also indehiscent, even though they may be free. When many ovules imbricate downwards and the calyx-tubes do not cohere (*Nauclea* and *Adina*), the fruits are dehiscent and formed of two cocci which separate from below upwards; the endocarp is not separable from the inferior calyx; the axis may persist after the falling of the cocci; the superior portion of the calyx may fall with the cocci, or it may persist as a crown to the axis. When all the ovules imbricate upwards the fruits are dehiscent, and the endocarp is coriaceous and separates from the inferior calyx; when the placentas are pendulous (*Mitragyna*), the capsules open at the top and the seeds

are broad and flat; when the placentas are linear with central attachment (*Uncaria*), the capsules open at the side, the two ends for the most part remaining joined, and the seeds are small with the long filiform processes at either end. In this last case the flowers, and especially the fruit, are generally pedicelled, so that they are less crowded than in the other forms, in which both the flowers and the fruit are always sessile.

Interfloral bracteoles also give characters of value in generic grouping. When the capsules open at the top, the bracteoles are paleaceous with spathulate tips, subglabrous, and so numerous as to completely separate the different flowers. More frequently (*Cephalanthus* and *Adina* and some species of *Uncaria*) the bracteoles are filiform and hairy with small spathulate tips, and in this case there is generally but one for each flower or even less. In some species of *Nauclea* there are between the flowers short thick glabrous cones reaching not much higher than the ovary. In other species bracteoles are wholly absent; but in these what seem to be rudiments of flowers are sometimes found between the perfect flowers. The receptacle is generally very hairy.

The inflorescence also provides characters of value in generic grouping. The simplest form is a solitary peduncle bearing the head of flowers at its apex, jointed and bearing two pairs of bracts at the joint; one pair of these bracts is apt to become foliaceous in character, and the other stipular. They may be seated near the top of the peduncles, when they are generally large and protective to the flower-head in bud, or they may be seated near the middle of the peduncle, in which case they are smaller; and it will be often found that they protect the flower in very early bud, the upper part of the peduncle lengthening disproportionately to the lower at a later stage: or, again, they may be seated below the middle of the peduncle, when they are rudimentary and functionless; in this case the young flower-head is often protected by large stipules at the base of the peduncle. In the genus *Uncaria* it is common to find such simple peduncles terminal and axillary, the terminal ones being generally ternate and the lateral ones always solitary, though exceptionally they are branched; some of the lateral ones in this genus are generally reduced to compressed recurved barren hooks. In the other genera it is very rare to find simple peduncles both terminal and axillary; in one species of *Sarcocephalus* terminal and axillary

peduncles are found on the same plant; and in *Adina* there is one species which has simple terminal peduncles, and other species which have simple lateral peduncles. In the great majority of species the peduncles are simple, though in several species they are compound. It often happens when a simple peduncle is terminal that two others arise at its base in the axils of the leaves on either side, the peduncles then being simple and ternate; this condition is common in *Uncaria* and *Nauclea*. In a single species (*Adina cordifolia*) the peduncles though axillary are simple and ternate, standing three together in a vertical plane. The peduncles may become compound by branching in the axils of the bracts, a secondary peduncle being given off in the axil of each foliaceous bract; the secondary peduncles are then themselves provided with bracts, though the original peduncle has no additional pair, so that the centre flower-head appears to be on a much shorter peduncle than the lateral ones. This branching of the peduncle occurs abnormally in *Nauclea*, but normally in *Mitragyna*, in which genus the secondary peduncles may themselves give off lateral peduncles from the axils of their foliaceous bracts. In some species of *Uncaria* the lateral peduncles may give off branches; but they then present two or three superposed sets of joints and bracts, more than one of which may give off branches. It may also happen in *Uncaria* that the leaves at the bases of the lateral peduncles are imperfectly developed, and the inflorescence then has the appearance of a racemoid cyme. In the African species all the lateral peduncles frequently remain sterile, the central terminal peduncle alone bearing flowers. In *Mitragyna macrophylla* it is not uncommon for the peduncle at the joint to split up into a large number of secondary peduncles of nearly equal size and length, so that the flower-heads are umbellate.

The stipules are generally interpetiolar and deciduous, but in three species of *Sarcocephalus* they are intrapetiolar, amplexicaul, and subpersistent. In *Mitragyna* and *Anthocephalus* they are very large, in the former genus broad and flat, but in the latter they enfold the bud. In the genera *Adina*, *Cephalanthus*, and *Uncaria* the stipules are smaller and frequently bifid.

All the species of *Uncaria* are climbing shrubs: those of other genera are erect, either trees or shrubs, although *Sarcocephalus esculentus* is said sometimes to climb. Sometimes the trees are of large enough size to provide timber, more often

they are smaller, and then are generally found growing on the banks of rivers, above the tidal limits.

Species of the Tribe are scattered over almost all the warmer regions of the earth, but they are most numerous in Malasia.

Classification and Distribution.

In arranging the species of this Tribe into natural groups, the genus *Uncaria* forms the most marked one. Whether its climbing habit and the long 4-angled internodes of the branchlets, or whether the solitary axillary peduncles, often converted into recurved and flattened hooks, or whether the linear placentas centrally attached with ovules, all imbricating upwards, and the fruit-capsules opening at the sides, with filamentous seeds, be considered, there is no difficulty whatever in distinguishing the species of *Uncaria* from those of other genera. Whilst, however, in the other species the character of the stigma is of generic value, in *Uncaria* various forms of stigma may be found. In the other groups too the presence of interfloral bracteoles is a generic character, but in *Uncaria* they may be present or absent: in the Asian species they are present in those whose fruit-capsules are sessile, and absent in those whose fruit-capsules are pedicelled, and these characters subdivide the genus in a natural way as far as the Asian and Malayan species are concerned; but the two American species, whilst they have interfloral bracteoles, have their capsules pedicelled. We can arrange the genus naturally into six groups: those without interfloral setæ will have four, one African and three Malayan; those with interfloral setæ will have two, one Asian and one American.

The genus *Uncaria* has the widest distribution; its species are most numerous in Malasia, and especially so in Malpina. Looking to the South-east, New Guinea, Australia, and the South Sea Islands, we find very little: *Uncaria pedicellata* has reached New Guinea, *Uncaria appendiculata*, which might easily rank as a marked variety of *U. ferrea*, has reached New Guinea, Australia, and the Solomon Islands; but these forms have changed so little that they must have migrated from Malasia at quite a recent date; only one peculiar species (*U. Bernaysii*) is known from New Guinea. Looking to the Northward, we find the Malayan forms which have pedicelled fruit and no interfloral bracteoles replaced on the Asian continent by species with

sessile fruit and filiform interfloral bracteoles. *Uncaria pedicellata* and *U. ferrea*, the two nost dominant Malayan forms, enter Tenasserim, and *U. pedicellata* has even got to Pegu and Cochin China; but there is only one peculiar species (*U. macrophylla*) in Asia with pedicelled fruit and no interfloral bracteoles; all the seven other Asian species have sessile fruit and filiform bracteoles. Two species with sessile fruit and filiform bracteoles have been found in Sumatra (*U. homomalla* and *U. Roxburghiana*), and Korthals gives Borneo as a locality for the latter; yet the species in Malasia which have pedicelled fruit and no bracteoles number more than twenty. The species in Tropical America number only two; they resemble the Asian forms in having interfloral bracteoles, but their fruits are pedicelled. To the Westward, *Uncaria* seems to stop at the Himalayan region, and not even to pass down the Peninsula of India; a variety of a Malayan species, *U. dasyoneura*, is found in Ceylon, but this perhaps has reached Ceylon without passing through India. The changes it has undergone are quite distinct, but not sufficient to give it specific rank. This practical absence of *Uncaria* from Southern India and Ceylon is most remarkable. In Madagascar, the Comoro Islands, and Tropical Africa a form is found which, though variable, does not readily fall into distinct species. It is very distinct from any of the other forms, but is more allied to the Malayan and American than to the Asian forms. Returning again to Malasia, it must be noticed that Malpina contains representatives of most of the Malayan forms, and seems to be now quite the headquarters of the genus.

Next to the genus *Uncaria* the genus *Mitragyna* stands most distinct, although the last to be founded, and still sometimes confounded with *Adina*. It consists of the only species with truly valvate corolla-lobes, it consists of the only species with truly mitrate stigma, it consists of the only species with ovules imbricating upwards on a pendulous placenta, it consists of the only species whose fruit-capsules open at the top. Its seeds are quite distinct, being not elongate but subovate. As in *Uncaria*, the endocarp becomes coriaceous and separates from the outer wall of the fruit-capsule. There are interfloral bracteoles as in *Adina* and *Cephalanthus*, but they are much more numerous and broader, they quite surround each flower, and are nearly glabrous excepting on the margins. In one or two species the calyx is truncate, in others the

lobes are quite distinct and imbricate, and in *Mitragyna speciosa* a single lobe may be many times larger than any of the others, simulating the top of the bracteole, but the lobes are never filiform or caducous.

The genus falls naturally into two groups. The one has large leaves, corolla-lobes hairy without, anthers not reflexed in flower, and short stigma; it consists of two of the three African species. The other has smaller leaves, corolla-lobes glabrous without, anthers reflexed between the corolla-lobes in flower, and stigma longer; it contains the Asian species together with *M. africana*, which is very closely allied to the Asian *M. parvifolia*.

The distribution of the genus *Mitragyna* is singularly different from that of *Uncaria*—it stretches from New Guinea to the West Coast of Africa. The most Eastern species is *M. speciosa*, found in Borneo, the Philippines, and New Guinea. *M. diversifolia* stretches from the Himalayas to the Philippines, Java, and the Cocos Islands; *M. parvifolia* occupies the Indian Peninsula and Ceylon, and passes through Burmah to Cochin China. *M. africana* stretches across Africa north of the Equator. *M. tubulosa*, which is a very distinct species, is found in Ceylon and in Southern India. The true African species *M. macrophylla* and *M. rubrostipulacea* are quite different from the Asian species, and must have been separated from them for a long time.

The genera *Anthocephalus* and *Sarcocephalus* together form a group distinguished at once by the spindle-shaped stigma, and by the seeds, though often flattened, not being produced or winged. The peduncles are always solitary and terminal, except in *S. Junghuhnii*, in which they may be ternate or sometimes axillary; they are jointed below the middle, and the bracts are small and functionless.

In *Anthocephalus*, though the flowers are crowded, the ovaries are not united, or at any rate they are very readily separable; whilst in *Sarcocephalus* they are so inseparably united as to appear to be imbedded in the receptacle. In both species of *Anthocephalus* and in *Sarcocephalus esculentus*, the African species, the placentas are linear and centrally attached as in *Uncaria*; but though in the upper part the ovules imbricate upwards, in the lower part the ovules imbricate downwards, and the seeds are not flattened or produced. In *Anthocephalus indicus* the upper part of each placenta is bifid, each arm entering

one of four hard, white, nut-like bodies, which are hollow from below and occupy the top of the ovary in fruit. *Nauclea macrophylla* of Roxburgh is closely allied to it, though the placenta is not bifid above, nor are the nut-like bodies present; it is not a *Nauclea* as the genus is now known and must be classed with *Anthocephalus*. The large stipules enfolding the bud distinguish at once both species of *Anthocephalus* from any other species of the Tribe.

All the species of *Sarcocephalus* have large arils to the seeds. The African species is usually placed in a separate section on account of the deciduous tips to the calyx-lobes; but the Asian *S. cordatus* has very similar tips, which, though not quite so caducous, do for the most part fall away. The really distinctive character of the African species is that the placentas are centrally attached and the seeds are ovoid and superposed; whilst in the Asian species the placentas are pendulous and the seeds are irregularly flattened and all imbricate downwards, though in *S. cordatus* there seems to be some variation. The Asian species fall into two sections—those in which the stipules are interpetiolar and deciduous, and those in which the stipules are amplexicaul and persistent. The latter section includes only two species. In the 'Flora of British India' they are left under *Nauclea*; but they must be placed under *Sarcocephalus* on account of the spindle-shaped stigma, the united ovaries, and the character of the seeds; in the persistent stipules they resemble *S. esculentus*, and in the large hairy persistent calyx-lobes they resemble *Anthocephalus*.

The former section consists of species which exhibit local differences and often graduate into one another, and in order to avoid confusing the synonymy I shall follow Miquel as closely as I can. I divide the section into two: in the one I place plants allied to *S. cordatus*, with large leaves and stipules, approaching *S. esculentus* in habit; and in the other I place plants allied to *S. subditus*, with smaller leaves and stipules, and approaching the genus *Nauclea* in their habit.

The distribution of the genera *Anthocephalus* and *Sarcocephalus* is singularly like that of *Mitragyna*, for they too stretch from New Guinea to the West Coast of Africa. This, on account of the peculiar structure of the stigma in either case, is somewhat remarkable. *Anthocephalus macrophyllus* is from the Moluccas; *Anthocephalus indicus* from India and Western

Malasia; *Sarcocephalus esculentus* stretches across Africa north of the Equator; *Sarcocephalus missionis* occupies India; and *Sarcocephalus Maingayi* occupies Borneo and Malpina. *Sarcocephalus cordatus* has a peculiar distribution. It is found in Ceylon, but not in India; it is common in the forests of Burmah in two forms—the one glabrous and the other pubescent; but I have seen no specimen from Malpina, south of Mergui, nor from Borneo, and only one doubtful specimen, not in flower, from Sumatra. It occurs in Cochin China, in the Philippines, and in Celebes; but in the latter islands it is always glabrous and graduates into a much larger form, *S. glaberrimus*. In Java it is common and probably always glabrous; specimens from Ceylon, Burmah, and Java can generally be distinguished from one another, occasionally the Javan specimens resemble those from the Philippines. The species also occurs in Australia, and the Australian specimens resemble the Javan ones, but the leaves are more often longer and with more numerous nerves. In the Moluccas and in New Guinea forms occur with large leaves and 14 pairs of nerves; some of the Molucca specimens are glabrous and some pubescent.

The plants allied to *S. subditus* are distributed all over Malasia, and extend into Cochin China and New Guinea; they exhibit local differences and do not fall readily into species. In habit they approach somewhat to the Malayan species of the genus *Nauclea*.

The genera *Cephalanthus*, *Adina*, *Nauclea*, and *Breonia* together have as wide a distribution as the Tribe. The genus *Breonia* consists of several species from Madagascar. In the Paris Herbarium there is a specimen labelled "Isle de France, *Commerson*," and another labelled "Guiane française (?)." Whilst, then, the occurrence of the genus in Mauritius is almost certain, and in Africa must be considered doubtful, it is probable that there are several unknown species still to be found in Madagascar. Baillon wished to reduce the genus to *Sarcocephalus* on account of the ovaries being inseparably united. But it is a natural genus; it differs from *Sarcocephalus* in the stigma, which is clavate and not spindle-shaped, in the peduncles, which are not terminal but axillary and flattened as in many kinds of *Nauclea*, and in the bracts, which are seated near the top of the peduncle and enclose the flower-head in bud. The stipules, too, are subtriangular and more or less folded.

The genus *Nauclea* is very abundant in Malasia, but, unlike the genus *Uncaria*, it is badly represented in Malpina and has its chief development further East. It resembles the genus *Sarcocephalus* in that the peduncles are always simple and terminal, though often ternate; it resembles *Breonia* in that the peduncles are often flattened; and it resembles *Adina* in the seeds and manner of opening of the fruit: *Adina* is, however, the only genus into which it graduates. The most typical are the Malayan species: they have stout style and globose stigma, anthers included, corolla-tube stout, calyx-lobes filiform, generally with thickened tips, and deciduous. The peduncles are sometimes slender and flattened, sometimes terete and thicken upwards, they are generally jointed just below the flower-head, and the bracts are generally large, though caducous. The stipules are flat and entire. Bracteoles are absent or stiff and glabrous. Looking to the South-east, two peculiar species are found in New Guinea, and one, *N. Forsterii*, is found in many of the South Sea Islands; this species has large villous clavate calyx-lobes. Looking to the North, two species with typical Malayan characters reach Cochin China; but the species of *Nauclea* which are found in India and two of those which are found in the Philippines depart from the typical Malayan form and approach *Adina*. In these Indian species the peduncles are jointed in the middle and the bracts are small, and bracteoles are always present, though they are stiff and glabrous, and quite different from the bracteoles of *Adina*. Two of these species were placed under *Adina* by Sir Joseph Hooker, and one of them was placed under *Adina* by Vidal; but they must all go together, and they go better with *Nauclea* than with *Adina*. They have the stout style and globose stigma, they have the included anthers and the deciduous calyx-lobes, and they have the simple terminal peduncles. *Nauclea sessilifolia*, stretching from the north of India to Cochin China, is a very peculiar form. *Nauclea Griffithii* is very close indeed to *Nauclea purpurea*—the one occupies the North of India, the other the Peninsula. *Nauclea zeylanica* differs from all the other species in having only one ovule in each cell and its calyx-lobes seem to be persistent; I have not seen its fruit. Thus the genus *Nauclea* resembles the genus *Uncaria* in undergoing a great change in passing from Malasia to India. There is also a similar change in passing to the South-eastern portion of the continent, for

Nauclea is there replaced by *Adina*; and the changes from *Nauclea* to *Adina* are in some respects curiously analogous to the changes from the Malayan species of *Uncaria* to the Asian species with sessile fruit and filiform bracteoles.

The branches of several species of *Nauclea* present hollow swellings for the use of ants. One of these species, *Nauclea strigosa*, Korth., differs from all other species in having the calyx-tubes united; but the superior portion of the calyx-tube does not thicken in the same way as it does in *Sarcocephalus*, and the fruit, instead of showing a number of depressions with dividing ridges, shows a number of conical elevations. The seeds are nearly as in other species of *Nauclea*; but the cocci cannot separate and fall away, and the endocarp becomes thickened and pith-like towards the top of the cell.

Although the falling of the calyx-lobes is often associated with the inability of the growing corollas to pass their crowded tips, yet in *Nauclea Chalmersii* the tips are subulate and not at all dilated, and they are said to be deciduous. *Sarcocephalus* is the only other genus in which deciduous calyx-lobes occur.

The genus *Adina* stretches from the North of India to Japan: one species descends the Peninsula of India and crosses to Ceylon; another species descends the Malay Peninsula and reaches Java; there is also a peculiar species in Malpina and another in the Philippines. The genus *Adina* is remarkable for the difference of inflorescence in the different species. There is only one, however, with simple terminal peduncles. The genus approaches both *Nauclea* and *Cephalanthus* in character. It differs from *Nauclea* not only by the filiform interfloral bracteoles, but also in the slender style with small clavate stigma, the anthers not included but seated on the mouth of the corolla-tube, the persistent calyx-lobes, and also in the bracts being small and not seated just below the flower-head. The African species *Adina microcephala* differs from the others in having its leaves ternately whorled; I have not seen the fruit, it may perhaps be indehiscent. The ovules are only three or four in each cell, and in this respect, as well as in the character of the peduncles and bracts, it has a resemblance to *Breonia*. The specimens which I have included under *Adina microcephala* present great differences in the length of the leaves and of the calyx-lobes.

The genus *Cephalanthus* is closely allied to *Adina*; it differs

only in having but one ovule in each cell of the ovary, and in the fruit being indehiscent. Although the genus consists of but few species it has a wide distribution. The first section of the genus consists of a few species allied to *Cephalanthus occidentalis*, Linn. This species stretches from Mexico and the West Indies to California and Canada, it is found also in Cochin China and Assam; it exhibits a great deal of variation, being sometimes glabrous and sometimes very hairy. The species allied to it are found growing within its area. The second section of the genus consists of two species found in Peru; they are almost identical except in the size of the flowers, and may be dimorphic forms of the same species. The third section of the genus consists of a single species found in South Africa. If the fruit of *Adina microcephala* is indehiscent, it would perhaps be more natural to class it under *Cephalanthus*. *Cephalanthus* is usually said to enter Malasia; but the evidence for this seems to rest entirely on a single plant, the *Cephalanthus aralioides*, Moritz (Zollinger, no. 1509), found near Tjikoyam in Java, on Aug. 21st, 1843. The plant was in bud only; it was dealt with several times by Miquel, who finally (Ann. Mus. Bot. Lugd.-Bat. iv. 183) concluded that it was *Adina polycephala*, and it has since been quoted as a synonym for both *Adina polycephala* and *Cephalanthus naucleoides*. There is a specimen in the British Museum: it may very well be *Adina polycephala*, but it is not a *Cephalanthus*.

If we compare the genus *Uncaria* with the genera *Cephalanthus*, *Adina*, and *Nauclea*, we find a curious analogy. Each has its greatest development in Malasia, each extends to America and Africa, and in each there is discontinuity between the Asian and African forms. *Adina microcephala* is analogous to *Uncaria africana* in its wide distribution and variation; both vary very considerably, but in both their subdivision into distinct species does not seem justified. There is no *Uncaria* to correspond to *Cephalanthus natalensis*, nor to the Indian species of *Nauclea*; but the development of the genus *Nauclea* in Malasia closely corresponds with the development of the genus *Uncaria* in that region, excepting that its headquarters are not in Malpina but further East. The most curious analogy is, however, in South-eastern Asia, where *Adina* corresponds with the species of *Uncaria* which have sessile fruit and exactly similar

bracteoles. The analogy between *Cephalanthus* and the American species of *Uncaria* is not, however, good. Whether the analogy between these two groups of plants is accidental, or whether they both bear similar witness to similar past conditions, I will not venture to guess.

The species of *Uncaria*, at any rate, bear the clearest witness to Malpina having a Malayan and not an Asian flora. If we except *Sarcocephalus cordatus*, which has an unusual distribution, and *Anthocephalus indicus*, which is often cultivated, we find in Malpina 21 species of the Tribe: of these, three belong to *Sarcocephalus* and are strictly Malayan, though one of them passes from the Philippines to Cochin China; three more belong to the genera *Adina* and *Nauclea*, of these one is peculiar, one is Malayan, and one is chiefly Asian but extends to Java; one belongs to *Mitragyna* and is found in Burmah, Java, and the Philippines; the other 14 all belong to the genus *Uncaria* and are all Malayan, not one is Asian. It is true that *Uncaria pedicellata* extends to Pegu and to Cochin China, and that *Uncaria ferrea* extends to Mergui, but these are dominant Malayan forms which have overstepped their boundaries. It is true also that *Uncaria ovata* has been recorded from Silhet, but this is probably an error. Probably *Uncaria lanosa*, *Uncaria trinervis*, and *Uncaria jasminiflora* are peculiar to Malpina; the other 11 species are all found at least in either Borneo or Sumatra. Thus out of the 21 species, four may be peculiar, two are common to Asia and Malasia, the remaining fifteen are found in other parts of Malasia and, with one exception, are not known to reach even as far north as Burmah.

If we examine the species found in Borneo we find that they number 28: of these only three reach Asia—*Anthocephalus indicus*, which is cultivated, *Nauclea synkorynes*, which crosses to Cambodia, and *Uncaria pedicellata*, which reaches Burmah and Cochin China. Of these 28 species, 5 only are peculiar to the island, 18 are found in Malpina or Sumatra, 9 are found in Java, and 8 in the Philippines; 13 being found in either Java or the Philippines, and of these 13, 9 are amongst the 18 found in Malpina and Sumatra.

Of the 28 species, one is *Anthocephalus*, five *Sarcocephalus*, six *Nauclea*, one *Mitragyna*, fifteen *Uncaria*; so that all the genera, excepting *Adina*, are as well represented in Borneo as

in Malpina. Neither of the two species which extend from Asia into the Malay Peninsula reach Borneo, though they both reach Java.

Notwithstanding that the genus *Uncaria* is so widely distributed, nearly half of its species grow in Borneo; yet whilst *Nauclea* is a peculiarly Malayan genus nearly a fifth only of its species grow in Borneo. The reason seems to be that the headquarters of the genus *Uncaria* are in Western Malasia, whilst the headquarters of the genus *Nauclea* are in Eastern Malasia.

A group of plants so well represented in the Malayan Archipelago might be expected to give evidence as to the value of isolation in the formation and limitation of specific differences; but so far as Western Malasia is concerned specific limits seem to take almost no account of the seas which separate Borneo, Sumatra, and Malpina. In Eastern Malasia it is probable that specific limits will be found to agree better with the position of the sea, but the islands there have been isolated for a much longer time.

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Tribe NAUCLEEÆ.

Flores numerosi, in receptaculum sphæricum densissime compacti, sessiles vel pedicellati, bracteolati vel ebracteolati. Calycis tubi pars inferior ovario adhærens, superior ab ovario libera, truncata vel lobata; lobi varii, sæpissime quinque, raro quatuor, valvati vel imbricati, caduci vel persistentes. Corolla anguste infundibularis; tubus elongatus; lobi breves imbricati vel valvati. Stamina ore vel fauce corollæ inserta; filamenta brevia.

Stylus longe exsertus; stigma capitatum, integrum vel bilobatum. Ovarium biloculare; placentæ lineares, ab apice loculorum pendulæ, vel medio septo affixæ. Ovula solitaria vel numerosa, sæpe complanata, sursum vel deorsum imbricata. Semina minuta, albuminosa, sæpissime complanata, sæpe alata.

Frutices vel arbores. Folia opposita vel verticillata, integra. Stipulæ integræ vel bifidæ, sæpissime interpetiolares caducæ, rarius intrapetiolares subpersistentes. Capitula pedunculata; pedunculi terminales vel axillares, solitarii vel terni, simplices vel racemosi. Bracteæ sæpissime quatuor, caducæ, in apice medio vel basi pedunculi sitæ, duæ folia, duæ stipulas simulantes.

Species 120, omnium regionum calidarum incolæ, in Malasia præsertim numerosæ.

Conspectus Generum.

Subtribus 1. ANTHOCEPHALIDÆ.

Pedunculi simplices, sæpissime terminales solitarii, prope vel infra medium bracteati. Corollæ lobi imbricati. Stigma fusiforme. Semina non alata; testa crustacea.

Calycum tubi non concreti .... 1. *Anthocephalus.*
Calycum tubi arcte concreti .... 2. *Sarcocephalus.*

Subtribus 2. CEPHALANTHIDÆ.

Pedunculi varii. Corollæ lobi imbricati. Stigma clavatum vel globosum. Placentæ pendulæ. Ovula pendula.

Fructus indehiscens. Semina non alata.
Calycum tubi arcte concreti .... 3. *Breonia.*
Calycum tubi non concreti .... 4. *Cephalanthus.*
Fructus dehiscens. Semina alata.
Pedunculi axillares vel racemosi...... 5. *Adina.*
Pedunculi terminales simplices ...... 6. *Nauclea.*

Subtribus 3. MITRAGYNEÆ.

Bracteæ sub apice pedunculi magnæ. Corollæ lobi valvati. Stigma mitriforme. Placentæ pendulæ. Ovula sursum imbricata. Semina ovata, complanata. Endocarpium coriaceum, a tubo calycis separans.

Bracteolæ numerosæ, paleaceæ .... 7. *Mitragyna.*

Subtribus 4. UNCARIÆ.

Pedunculi sæpissime simplices, axillares, solitarii, sæpe in cirrhos uncinatos steriles mutati. Corollæ lobi imbricati. Placentæ medio septo affixæ. Ovula numerosa, sursum imbricata.

Semina filiformia. Endocarpium coriaceum, a tubo calycis separans.

Frutices scandentes .... 8. *Uncaria.*

Genus dubiæ affinitatis .... 9. *Paracephaelis.*

I. Anthocephalus.

(Typus *A. indicus.*)

Flores in capitulum globosum compacti, ebracteolati, calycibus non concretis. Calycis tubus sublinearis, subglaber, parte superiore 2 mm. longâ; lobi 5, oblongo-lineares, sparse hirsuti, persistentes. Corolla tubuloso-infundibularis, glabra; lobi 5, imbricati. Stamina 5, ore corollæ inserta; antheræ lineares, apiculatæ, basi sagittatæ. Stylus longe exsertus, stigmate fusiformi. Ovarium biloculare; placentæ lineares, medio septo affixæ. Ovula numerosa, superiora ascendentia, inferiora descendentia. Semina minuta, ellipsoidea; funiculus brevissimus; testa submembranacea; albumen carnosum.

Arbores, ramulis crassiusculis teretibus. Folia opposita, coriacea. Stipulæ elongatæ, interpetiolares, amplectentes, caducæ. Pedunculi crassi, solitarii, terminales, infra medium bracteati; bracteæ parvæ.

Anthocephalus, *A. Rich.* (1834), *in Mém. Soc. Hist. Nat. Paris,* v. p. 236; *Korth. Obs. Naucl. Ind.* p. 20, et *Verh. Nat. Gesch.* p. 154.

Sarcocephalus, *Baill. Nat. Hist. Pl.* vii. p. 496 *Kurz, For. Fl.* ii. p. 63.

Nauclea, *Linn., Roxb. et auct. pro parte.*

Synopsis Specierum.

Folia petiolata .... 1. *indicus.*
Folia sessilia .... 2. *macrophyllus.*

1. Anthocephalus indicus, *A. Rich.*

Arbor 60 metr. Internodia 1–2 cm. Folia 2 dm. longa, 1 dm. lata, elliptico-lanceolata vel ovata, apice acuta, supra glabra, infra glabra vel pubescentia, 10–14-nervia, nervis transversis tenuibus. Petioli 25 mm. Stipulæ 2 cm., glabræ. Pedunculi 25 mm.; bracteæ 2 mm., infra medium affixæ. Florum capitula 4 cm., aurantiaca, noctu odorata; stigmata alba. Corollæ tubus 9 mm.; lobi lineares. Calycis lobi 3 mm. Ovarium inferne

biloculare, superne 4-locellatum; placentæ superne bifidæ, ramis intra locellos ascendentibus. Fructus subcarnosus, locellis in nuculas albas duras cavas mutatis.—*A. indicus*, A. Rich. in Mém. Soc. Hist. Nat. Paris, 1834, v. 237. *A. morindæfolius*, Korth. Verh. Nat. Gesch. p. 154, t. 48. *A. ? Cadamba*, Miq. Fl. Ind. Bat. ii. 135; Bedd. Fl. Syl. 127, t. 35; Brand, For. Fl. 261. *Nauclea Cadamba*, Roxb. Fl. Ind. ii. 512. *Sarcocephalus Cadamba*, Kurz, For. Fl. Burma, ii. 63; Wall. List, n. 6088 excl. C.

MALASIA.—Sumatra (Korthals, n. ? ex Herb. Lugd.-Bat.). Java (Zollinger, n. 1045). Borneo. Malay Peninsula. New Guinea.

S.E. ASIA.—Tonquin (Balansa, n. 2680).

INDIA.—Upper Assam (Jenkins, n. 494). Sikkim; alt. 2000 ft. (Hooker). Silhet (Wallich, n. 6088). Darjeeling (Griffith, n. 2752). Moradabad (Thomson, n. 1410). Hort. Dacca (Hooker). Hort. Calc. (Wallich, n. 6088). Cochin and Travancore (?, n. 271). Ceylon (Thwaites, n. 1659).—Generally cultivated.

Richard's synonymy is erroneous. Miquel's description of *Anthocephalus indicus* is a description of *Nauclea purpurea*, Roxb. *Anthocephalus chinensis*, Walp., is another error arising from Richard's erroneous synonymy. *Nauclea morindæfolia*, Blume, is distinct; its flowers are still unknown, but its stipules are not those of *Anthocephalus.*

The fruits are certainly free, and Miquel so describes them. Kurz, however, says, "capsules connate into a fleshy spherical syncarp;" but of *Sarcocephalus cordatus* he says "capsules somewhat fleshy, densely packed into a syncarp, but hardly cohering." The first quotation certainly applies to *S. cordatus*, and the second to *A. indicus*. Since the time of Kurz, *Anthocephalus* has been often erroneously credited with confluent fruits. Trimen in his 'Handbook' describes the fruits as capsular, and says "capsule about $\frac{1}{4}$ in., compressed, angular, closely packed, but scarcely confluent." The New Guinea locality is given by Warburg in Engl. Jahrb. xiii. 129. The figures of the stipules and of the ovary in Beddome's 'Flora Sylvatica,' t. 35, are incorrect.

PLATE 4.—38. Stipules, nat. size. 39. Flower, nat. size. 40. Flower, enlarged. 41. Calyx-lobe. 42. Stigma. 43. Section of fruit.

2. ANTHOCEPHALUS MACROPHYLLUS, *Hav.*

Typi in Herb. Kew., Mus. Brit., etc.

Folia 3 dm. longa, 2 dm. lata, ovata, apice obtusa, sessilia, basi auriculis magnis caulem amplectentibus ornata, supra glabra, infra pubescentia, 16-nervia. Stipulæ 5 cm. Internodia 2 cm., castanea, pubescentia. Pedunculi 8 cm., crassi. Florum capitula 7 cm. Corollæ tubus 1 cm., glaber, lobis oblongis. Stigma 5 mm. Antheræ $2\frac{1}{2}$ mm. Calycis lobi 9 mm., hirsuti, basi glandulis

nigris instructi. Ovarium biloculare; placentæ lineares, non bifidæ.—*Nauclea macrophylla*, Roxb. Fl. Ind. i. 511, et ed. Carey & Wall. ii. 120.

MALASIA.—Amboina (herbb. Blume, Calcutta).

This plant was introduced into the Calcutta Gardens in 1797. The trees began to blossom in 1810; they were described in Roxburgh's 'Flora Indica.' Dr. King informs me that one tree is still alive, but is now a ruin; its great stem is hollow and is the home of a colony of big bees, who resent anybody going up to collect specimens.

PLATE 4.—32. Stipule, nat. size. 33. Flower, nat. size. 34. Flower, enlarged. 35. Calyx-lobes, enlarged. 36. Stigma. 37. Section of ovary.

II. SARCOCEPHALUS.
(Typus *S. esculentus.*)

Flores in capitulum globosum compacti, ebracteolati, calycibus arcte concretis. Calycis lobi 4–5, persistentes vel caduci. Corolla infundibulari-tubulosa, glabra; lobi 4–5, imbricati, glabri vel pubescentes. Stamina ore vel fauce corollæ inserta, antheris ovatis vel oblongis. Stylus longe exsertus, stigmate fusiformi. Ovarium biloculare; placentæ pendulæ ovulis deorsum imbricatis, vel septo adnatæ. Syncarpium globosum, ambitu carnosum, loculorum parietibus tenuibus, septis membranaceis. Semina ovoidea superposita, vel compressa deorsum imbricata, non alata; funiculi fungosi; testa crustacea; albumen carnosum.

Frutices vel arbores. Folia petiolata. Stipulæ interpetiolares caducæ, vel intrapetiolares persistentes. Pedunculi simplices, sæpissime solitarii terminales, infra medium bracteolati. Bracteæ parvæ.

Sarcocephalus, *Afzel. ex R. Br. in Tuckey's Congo, App.* p. 467 (1818); *Sabine, in Trans. Hort. Soc.* v. 422 (1824); *Miq. Fl. Ind. Bat.* ii. 132; *Benth. et Hook. f. Gen. Pl.* ii. 29.

Platanocarpum, *Korth. Obs. Naucl. Ind.* p. 18, et *Verh. Nat. Gesch.* p. 151.

Nauclea, *Linn. Sp. Pl.* ed. 2, i. 243, *et auct.*

Cephalina, *Thonn. in Schumacher, Beskr. Guin. Pl.* p. 105 (1827).

Synopsis Specierum.

Sectio 1.

Stipulæ breves, intrapetiolares, persistentes. Calycis lobi parvi, subclavati, decidui. Placentæ septo adnatæ; ovula supe-

riora sursum imbricata, inferiora deorsum imbricata. Semina ovoidea superposita.

Folia sæpe cordata .... 1. *esculentus.*

Sectio 2.

Folia sæpe cordata. Stipulæ magnæ, 2–3 cm., interpetiolares, complanatæ, caducæ. Calycis lobi parvi, subclavati, decidui. Stamina ore corollæ inserta. Placentæ pendulæ; ovula deorsum imbricata. Semina complanata, deorsum imbricata.

Folia 7–10-nervia .... 2. *cordatus.*
Folia 9–12-nervia .... 3. *glaberrimus.*
Folia 11–14-nervia .... 4. *undulatus.*

Sectio 3.

Folia non cordata. Stipulæ 5–15 mm., ovatæ, interpetiolares, complanatæ, caducæ. Stamina ore corollæ affixa. Placentæ pendulæ; ovula deorsum imbricata. Semina complanata, deorsum imbricata.

Folia magis quam dimidio longiora quam lata........................... 5. *Junghuhnii.*
Folia minus quam dimidio longiora quam lata.
Florum capitulum 16 mm. diam.
Folia coriacea, glabra.
Petioli 5 mm. .... 6. *subditus.*
Petioli 15 mm. .... 7. *mitragynus.*
Folia pubescentia .... 8. *dasyphyllus.*
Folia chartacea .... 9. *parvus.*
Florum capitulum 3 cm. diam.
Folia glabra .... 10. *tenuiflorus.*
Folia hirsuta .... 11. *hirsutus.*

Sectio 4.

Stipulæ intrapetiolares, persistentes. Calycis lobi magni, clavati, hirsuti, persistentes. Stamina ore corollæ inserta. Placentæ pendulæ. Semina irregulariter compresssa, deorsum imbricata.

Stipulæ 5 mm. .... 12. *missionis.*
Stipulæ 15 mm. .... 13. *Maingayi.*

1. SARCOCEPHALUS ESCULENTUS, *Afzel.* *Typus* (?).

Arbor 12 m. Folia 14 cm. longa, 9 cm. lata, ovata, breviter acuminata, basi sæpe cordata, coriacea, glabra vel subtus pubescentia, 6–8-nervia. Petioli 1–3 cm., glabri vel pubescentes. Stipulæ 4 mm., intrapetiolares, basi subconnatæ, margine hirsutæ.

Internodia glabra vel pubescentia. Pedunculi 13–30 mm., infra medium bracteati. Bracteæ parvæ. Florum capitulum 4 cm. Corollæ tubus 9 mm., glaber. Stamina fauce corollæ insertæ; antheræ oblongæ, in corollæ tubo inclusæ. Stylus 19 mm., stigmate 2 mm. Calycis tubi pars superior 1 mm., intus hirsuta; lobi sæpissime 4, 2½ mm. longi, caduci, filiformes, superne dilatati hirsuti. Placentæ elongatæ septo adnatæ, ovulis superioribus sursum imbricatis, inferioribus deorsum imbricatis. Fructus in syncarpium rubrum, esculentum, connati, apice depresso-excavati. Semina ovoidea, superposita.—*S. esculentus*, Afzel. ex R. Br. in Tuckey's Congo, App. v. 467; Sabine, in Trans. Hort. Soc. v. 422; Hiern, in Oliver, Fl. Trop. Afr. iii. 39. *S. Russeggeri*, Kotschy, ex Schweinf. Reliq. Kotsch. 49; Hiern, in Oliver, Fl. Trop. Afr. iii. 39. *S. sambucinus*, K. Schum. in Engl. et Prantl, Pflanzenf. Teil iv. Abt. 4 & 5, S. 59. *Nauclea sambucina*, Winterbottom, Account of Sierra Leone, ii. 25. *N. latifolia*, Smith, in Rees's Cyclop. xxiii. *Cephalina esculenta*, Schumacher, Besckr. Guin. Pl. p. 105.

Var. *a. Eu-esculentus.*

Folia 7–8-nervia. Petioli 10–15 mm. Internodia 2–5 cm. Pedunculi 15 mm. Syncarpium majus (?). Nervi foliorum, petioli, et pedunculi sæpissime pubescentes.—West Africa.

Var. *b. Russeggeri.*

Folia 6–7-nervia. Petioli 15–30 mm. Internodia 5–10 cm. Pedunculi 30 mm. Syncarpium minus (?). Nervi foliorum, petioli, ramuli, et pedunculi sæpissime glabri.—Central Africa.

West Africa [var. *a*].—Niger (Barter, n. 1244). Lagos (Miller, n. 132). Bagrao river (Mann, n. 801). Sierra Leone (Scott Elliot, n. 5357 and n. 4885), (Vogel, n. 172). Senegal (?). Gambia (Ozanne, n. 23).

Central Africa [var. *b*].—Æthiopia (Kotschy, n. 511). Sources of the Nile (Madi Lurn, Speke & Grant n. 680). Djur Land (Schweinfurth, n. 1289, n. 3252, n. 1626, n. 1733). Niamniam Land (Schweinfurth, n. 3746).

The bark of this plant is used by natives for medicine; it has been recommended for indigestion, and said to have an action similar to that of cocaine. The fruit is edible. The plant is said sometimes to climb, but this must be regarded as doubtful, for under the name of "fig" it has been confused with another plant which commences life epiphytically and yields a rubber.

Plate 4.—21. Flowers. 22. Section of calyx and ovary. 23. Stigma 24. Seed.

2. SARCOCEPHALUS CORDATUS, *Miq.* *Typus* (?).

Arbor. Ramuli pallidi. Folia maxime varia, 14 cm. longa, 10 cm. lata, ovata, basi sæpe cordata, aliquanto in petiolum decurrentia, apice obtusa, glabra vel subtus pubescentia, 7–10-nervia. Petioli 25 mm. Stipulæ 2 cm., oblongæ vel ovatæ. Pedunculi solitarii, 3 cm., infra medium bracteati. Bracteæ parvæ, 3 mm. Florum capitula 3 cm., odorata, alba, flavescentia. Corollæ tubus 7 mm.; lobi 4–5, glabri. Stamina ore corollæ inserta; antheræ obscure apiculatæ, usque ad medios lobos attingentes. Stylus 16 mm. Calycis tubi pars superior 2 mm.; lobi 1 mm. longi, subclavati, subglabri, sæpissime decidui. Syncarpium 25 mm., esculentum, apice depresso-excavatum; semina irregulariter complanata, deorsum imbricata. Placentæ pendulæ. Arilli flavi, magni.—*S. cordatus*, Miq. Fl. Ind. Bat. ii. 133; Bedd. Fl. Sylv. t. 318; Kurz, For. Fl. Burma, ii. 63; Hook. f. Fl. Brit. Ind. iii. 22. *S. Horsfieldii*, Miq. loc. cit. 134. *Cephalanthus orientalis*, Linn. Sp. Pl. ed. 1, 95. *Nauclea orientalis*, Linn. Sp. Pl. ed. 2, 243. *N. cordata*, Roxb. Fl. Ind. i. 509. *N. coadunata*, Roxb. in Herb.; Smith, in Rees's Cyclop. *N. Roxburghii*, G. Don, Gen. Syst. iii. 467. *N. Wallichiana*, R. Br. in Wall. List, n. 6098. *N. parvifolia*, Wall. List, n. 6093. *N. undulata*, Wall. List, n. 6094. *N. macrophylla*, Blume, Bijdr. p. 1010. *N. grandifolia*, DC. Prodr. iv. 345. *Platanocarpum cordatum*, Korth. Obs. Naucl. Ind. 16.

Var. *a.* Folia glabra.

Var. *b.* Folia subtus pubescentia. Stipulæ et pedunculi pubescentes.

MALASIA.—Java (Blume, n. ?), (Miquel, n. ?). Celebes (Riedel, n. ?). Philippines (Vidal, n. 1479 & n. 2954), (Cumming, n. 1245 & n. 1550).

AUSTRALIA.—Queensland (F. v. Mueller, n. ?). Victoria River (F. v. Mueller, n. ?).

S.E. ASIA.— Cochin China (Pierre, n. 3163). Macao (Hance ex Hort.).

INDIA.— Mergui (Griffith, n. 1146). Burmah (Griffith, n. 2754). Hort. Calc. (Griffith, n. 2749), (Wallich, n. 6094). Ceylon (Walker n. ?), (Walker, n. 155), (Thwaites, n. 1658).

Kurz says that in Burmah the tree sheds its leaves in the hot season and flowers in May, and that the wood is soft and soon decays. Its distribution is very peculiar. It is found in Ceylon, but not in India; it is common in the forests of Burmah in the glabrous and in the pubescent form; but I have seen no specimen from the Malay Peninsula south of

Mergui, nor from Borneo, and only one doubtful specimen not in flower from Sumatra. It occurs in Cochin China, in the Philippines, in Celebes, and in Java; but from these islands I have seen only glabrous specimens. In the Philippines the specimens have very coriaceous stipules, and graduate into the much larger form described as *S. glaberrimus.* The Javan specimens can usually be distinguished from both the Ceylon and the Burmah specimens, but they are very variable: occasionally they resemble the Philippine specimens and have very coriaceous stipules; more often they approach the Australian forms, which often have longer leaves from 9–11-nerved. In the Moluccas and New Guinea the species seems to be replaced by the forms described under *S. undulatus.* The subdivision into species of the section of the genus to which *S. cordatus* belongs is indeed not yet altogether satisfactory. I have therefore tried to follow Miquel.

In respect of the ovaries there seems to be some variation. Beddome (Fl. Syl. t. 318) says that " when the fruit is ripe the upper seeds become erect," probably he meant to say that in some fully ripe specimens he found the upper seeds erect, as in *S. esculentus* and *Anthocephalus.* Bentham (Fl. Austral. iii. p. 402) describes the seeds of *S. cordatus* as solitary or two superposed. In one Australian specimen which I examined there were several pendulous seeds imbricating downwards; it might be easy for these to be reduced by abortion, but if they ever become superposed as in *S. esculentus* the fact would be interesting. Roxburgh says that the placenta is attached to the partition a little above its middle, that the ovules are numerous and imbricated, but that most of them abort, and there are only a few oblong imbricated seeds.

3. Sarcocephalus glaberrimus, *Miq.*

Typus in Herb. Haenke.

Folia 35 cm. longa, 24 cm. lata, ovata, apice obtusa, basi cordata, glabra, maxime coriacea, 10–12-nervia, nervis latis. Petioli 25 mm. Stipulæ 35 mm., ovatæ, valde coriaceæ. Pedunculi 4 cm., crassi. Capitula (sine corollis) 25 mm. Calycis tubi pars superior cum lobis 4 mm. longa.—*S. glaberrimus,* Miq. Fl. Ind. Bat. ii. p. 133. *Nauclea glaberrima,* DC. Prod. iv. 344.

Malasia.—Celebes (Teysmann, n. ?). Philippines (Vidal, n. 2957).

The extreme specimens of this form are very different from the Ceylon forms of *S. cordatus*; but it seems likely that almost all the intermediate forms can be found in the Philippine Islands. I have not seen the type specimen, which is in Herb. Haenke.

4. Sarcocephalus undulatus, *Miq.*

Folia 3 dm. longa, 22 cm. lata, ovata, apice obtusa vel breviter acuminata, basi aliquanto in petiolum decurrentia, undulata,

glabra vel pubescentia, 14-nervia. Petioli 25 mm. Stipulæ magnæ, submembranaceæ, 3–4 cm. longæ. Pedunculi 25–40 mm. Capitula (sine corollis) 1 cm. Corollæ tubus 7 mm. Stylus 14 mm. Calycis pars superior cum lobis 3 mm. longa.—*S. undulatus*, Miq. Fl. Ind. Bat. ii. 133. *S. buruensis*, Miq. Ann. Mus. Bot. Lugd.-Bat. iv. 180. *S. cordatus*, K. Schum. et Hollr. Fl. Kaiser. Wilh. 127. *Nauclea undulata*, Roxb. Fl. Ind. ii. 117, et i. 508. *N. stipulacea*, Wall. List, n. 6090.

Var. *a. glabra.* Folia petioli pedunculi glabri.

Var. *b. buruensis.* Folia subtus pubescentia.

Malasia.—Ex Hort. Calc. (Roxburgh, n. ?). Ceram (De Vriese). Boeroe; (De Vriese).

New Guinea.—Kaiser Wilh. Land (Hellwig, n. 187), (Hollrung, n. 255 & n. 811).

S. buruensis, Miq., appears to differ from *S. undulatus* only in being pubescent. The form found in New Guinea may be distinct, the leaves are sometimes sharply but shortly acuminate; it is, however, closer to *S. undulatus* than to *S. cordatus*. At the end of the last century this species was planted in the Calcutta Gardens: at various times since then, what appears to be a pubescent form of *S. cordatus* has been distributed to Herbaria as *Nauclea undulatus*, Roxb.; one of these is Wall. List, n. 6094. *Nauclea stipulacea*, Wall. List, n. 6090, may be *N. undulata*, Roxb.; but it does not quite agree with Miquel's specimens of *S. undulatus*.

5. Sarcocephalus Junghuhnii, *Miq.*

Typus in Herb. Leiden.

Folia magis quam dimidio longiora quam lata, 12 cm. longa, 7 cm. lata, ovata, vel obovato-lanceolata, breviter acuminata, coriacea, glabra, nervis 7–8 subtus prominentibus. Petioli 15 mm. Stipulæ 8–15 mm. Ramuli crassiusculi. Pedunculi longitudine varia, pubescentes, solitarii v. ternati. Bracteæ 3 mm., sæpe connatæ, infra medium pedunculi sitæ. Florum capitulum 18 mm. Corollæ tubus 5 mm.; lobi 4–5. Antheræ breves, ad medios lobos non attingentes. Stylus 7 mm. Calycis lobi brevissimi. Fructus in syncarpium 2 cm. diam. connati, depressionibus cupularibus, jugis obtusis.—*S. Junghuhnii*, Miq. Fl. Ind. Bat. ii. 133; Hook. f. Fl. Brit. Ind. iii. 23.

Var. *a.* Pedunculi solitarii.

Var. *b.* Pedunculi sæpissime ternati.

Malasia.—Malacca (Griffith, n. 2772), (Maingay, n. 1696, n. 2630). Penang (Curtis, n. 303). Borneo; Sarawak (Beccari, n. 1430, n. 2683,

n. 3200). Sumatra; Padang (Beccari, n. 890). Philippines; Luzon (Vidal, n. 797).

S.E. Asia.—Cambodia (Pierre, n. 605).

This species presents much variation, and the limits between it and allied species are not yet satisfactorily defined; so that here again I have endeavoured to follow Miquel. His type specimens are from Sumatra; the peduncles are solitary. The specimens from the Malay Peninsula which Sir Joseph Hooker put into this species seem to differ little from the Sumatran specimens excepting that the peduncles are almost always ternate. Bornean specimens collected by Beccari have solitary peduncles and a somewhat more robust habit. In Sumatra, Borneo, and the Malay Peninsula the specimens of *S. subditus* are readily separable on account of their narrower, less coriaceous leaves, and the ridges on the syncarpium being more irregular and sharper; but the specimens of *S. subditus* from Java which I have seen seem intermediate in their characters. Specimens from the Philippines, which are badly preserved, show that there is a form there which may belong to this species: some of its peduncles are axillary. Specimens from Cambodia also exist which may belong to this species. In Ceram it is represented by *S. mitragynus*, and in New Guinea by *S. tenuiflorus*.

6. Sarcocephalus subditus, *Miq.*

Typus in Herb. Leiden.

Arbor parva. Ramuli tenues. Folia 9–16 cm. longa, 4–8 cm. lata, elliptica, acuminata, glabra, 7-nervia. Petioli 5 mm., tenues. Stipulæ 5 mm., ovatæ. Pedunculi solitarii, 25 mm., tenues, pubescentes, ad medium vel infra medium bracteati; bracteæ 2 mm. Florum capitulum 20 mm. Corollæ tubus 5 mm.; lobi extra hirsuti. Antheræ breves, usque ad medios lobos attingentes. Stylus 8 mm. Calycis lobi brevissimi, pubescentes. Syncarpium 2 cm., depressionibus cupularibus, jugis acutis erosis. Semina nigra, irregulariter compressa, deorsum imbricata.—*S. subditus*, Miq. Fl. Ind. Bat. ii. 133; Hook. f. Fl. Brit. Ind. ii. 22. *Platanocarpum subditum*, Korth. Verh. Nat. Gesch. p. 133, t. 32.

Malasia.—Malacca (Griffith, nn. 2770, 2771). Borneo: Banjermassin (Motley, n. 677); Sarawak (Haviland, n. 710); incert. loc. (Korthals, n. ?), (Teysmann, n. 11581). Sumatra; Palambang (Miquel, n. ?). Java (Teysmann).

Most of the specimens of this species seem to agree together; Teysmann, Borneo (ex Herb. Hort. Bot. Bog. n. 11581), has, however, much more elongate leaves measuring 12 by 4 cm., and the nerves in 9 pairs. The Javan specimens, as already stated, have broader and more coriaceous

leaves. Korthals figures the ovary with ovules imbricating upwards; I have dissected many dried specimens, and have never found anything at all resembling his figure of the ovary.

7. SARCOCEPHALUS MITRAGYNUS, *Miq.*

Typus in Herb. Leiden.

Folia 15 cm. longa, 7 cm. lata, elliptica, apice breviter et obtuse acuminata, basi attenuata, glabra, nervis 7, duobus inferioribus obliquis. Petioli 15 mm. Pedunculi 4 cm., tenues, superne pubescentes, solitarii. Florum capitulum 16 mm. Stigma fusiforme, 1 mm. longum.—*S. mitragymus*, Miq. Ann. Mus. Bot. Lugd.-Bat. iv. 180.

MALASIA.—Ceram.

This species is closely allied to *S. subditus*, and is distinguished chiefly by the longer petioles and peduncles.

8. SARCOCEPHALUS DASYPHYLLUS, *Miq.*

Typus (?).

Folia 8 cm. longa, 4 cm. lata, ovato-elliptica, obtuse acuminata, subtus pubescentia, 7-nervia. Petioli 6 mm., pubescentes. Ramuli tenues, pubescentes. Pedunculi solitarii, pubescentes, tenues, infra medium bracteati. Syncarpium 18 mm., depressionibus cupularibus, jugis acutis erosis.—*S. dasyphyllus*, Miq. Fl. Ind. Bat. ii. 133.

MALASIA.—Sumatra; Lampong (Teysmann, ex herb. Miquel).

I have seen but one specimen of this, in fruit.

9. SARCOCEPHALUS PARVUS, n. sp.

Typi (*Haviland*, 1892) *in Herb. Kew. etc.*

Ramuli tenues, pubescentes. Folia 1 dm. longa, 3 cm. lata, anguste elliptica, apice longe et acute acuminata, basi attenuata, chartacea, glabra, in plantis exsiccatis umbrina, 5-nervia. Petioli 8 mm., pubescentes. Stipulæ 2 mm., ovatæ, caducæ. Pedunculi solitarii, terminales, 15 mm., tenues, pubescentes, ad medium vel infra medium bracteati; bracteæ 4 mm. Capitulum 16 mm. Corollæ tubus 4 mm.; lobi 4, intus sparse hirsuti. Antheræ breves, cordatæ, ad medios lobos attingentes. Stylus 6 mm., stigmate subovoideo. Calycis lobi breves, pubescentes. Syncarpium 8 mm., subleve. Semina in loculis 4–5, deorsum imbricata, irregulariter complanata; testa nigra, crustacea, arillo magno.

MALASIA.—Borneo; Lundu (Haviland, n. 1519).

10. Sarcocephalus tenuiflorus, *Hav.*

Typi (*Hollrung*, 829) *in Herb. Berol., Kew., Leiden., etc.*

Folia 7 cm. longa, 3 cm. lata, obovata v. oblanceolata, apice rotundata vel abrupte acuminata, basi attenuata, subcoriacea, glabra, 6–7-nervia. Petioli 1 cm. Stipulæ 6 mm. Ramuli tenues, juniores obtuse angulati. Pedunculi tenuissimi, 45 mm., glabri, prope ad medium bracteati. Florum capitulum 3 cm. Corollæ tubus 1 cm., tenuissimus; lobi glabri. Antheræ ovatæ. Stylus 14 mm. Calycis lobi 1 mm., subspathulati.—*S. subditus*, K. Schum. et Hollr. Fl. K. Wilhelmsland [1889], p. 127.

New Guinea.—Kaiser Wilhelmsland (Hollrung, n. 829).

11. Sarcocephalus hirsutus, n. sp.

Typus (*Haviland* n. 3406) *in Herb. Kew.*

Internodia 25–40 mm., sæpe pubescentes. Folia 12 cm. longa, 5 cm. lata, elliptica, apice longe acuminata, basi subrotundata, submembranacea, supra glabra, subtus hirsuta, 7–8-nervia. Petioli 5 mm., hirsuti. Stipulæ 1 cm. Pedunculi solitarii 2 cm., hirsuti, infra medium bracteati; bracteæ 5 mm. Capitulum 3 cm. Corollæ tubus 6 mm.; lobi 4 v. 5, glabri. Antheræ ovatæ. Stylus 15 mm. Calycis tubi pars superior hirsuta, obscure lobata. Ovula complanata, deorsum imbricata.

Malasia.—Borneo; Saribas (Haviland, nn. 1568, 3406).

12. Sarcocephalus missionis, *Hav.*

Folia 14 cm. longa, 5 cm. lata, elliptico-lanceolata, obtusa, aliquanto in petiolum decurrentia, submembranacea, glabra, in plantis exsiccatis fuliginea, 12-nervia. Petioli 1 cm. Stipulæ intrapetiolares, subpersistentes, subtriangulares, 5 mm. longæ. Pedunculi solitarii, 25 mm., infra medium bracteati, bracteis basalibus additis. Bracteæ 3 mm., connatæ, supersistentes. Capitulum (sine corollis) 25 mm. Corollæ flavæ; tubus 7 mm.; lobi extra et intus hirsuti. Antheræ lanceolatæ, apiculatæ, medios lobos excedentes. Stylus 15 mm., stigmate fusiformi. Calyx albo-tomentosus; tubi pars superior 2 mm.; lobi 2 mm., persistentes, oblongi, subclavati. Fructus in syncarpium connati. Semina irregulariter complanata, deorsum imbricata; testa nigra crustacea, arillo magno.—*Nauclea missionis*, Wight & Arn. Prod. 392; Hook. f. Fl. Brit. Ind. iii. 27. *N. elliptica*, Dalz. & Gibs. Bomb. Fl. 118. *N. oblongata*, Miq. in Herb. Hohenack. n. 717, ex Hook. f. Fl. Brit. Ind.; *N. orientalis*, Linn. Sp. Pl. ed. 2, 243 pro parte. *Cephalanthus orientalis*, Linn.

Sp. Pl. ed. 2. 95 pro parte. *Katu Tsiaca*, Rheede, Hort. Malab. iii. p. 29, t. 33.

INDIA.—N. Kanara (Talbot, n. ?). Malabar (?). Quilon (Wight, Kew Distr. n. 1300). Peninsula (Dalzell, n. ?).

A tree growing on the banks of streams.

13. SARCOCEPHALUS MAINGAYI, *Hav.*

Typus (*Maingay*, *Kew Distr.* n. 823).

Folia 14 cm. longa, 7 cm. lata, obovato-elliptica, apice breviter abrupte acuminata, basi attenuata, subcoriacea, supra glabra, subtus pubescentia, 10–14-nervia. Petioli 15 mm., complanati. Stipulæ intrapetiolares 10–14 mm., persistentes, basi connatæ. Pedunculi 15 mm., supra medium bracteati; bracteæ pubescentes. Capitulum 3 cm. Corollæ tubus 8 mm.; lobi lanceolati, extra et intus tomentosi. Antheræ lanceolatæ apiculatæ, medios lobos excedentes. Stylus 13 mm., stigmate fusiformi. Calycis tubi pars superior brevis; lobi 4 mm., subclavati, tomento isabellineo. Ovaria (?).—*Nauclea Maingayi*, Hook. f. Fl. Brit. Ind. iii. 27.

MALASIA.—Malacca (Maingay, n. 1288). Borneo: Sarawak (Beccari, n. 681); loc. incert. (Teysmann).

This species is closely allied to *S. missionis*. I have not, however, examined the ovaries, and all the specimens of fruit which I have seen have had their interior eaten by insects. In this and the last species the surface of the syncarpium is hidden by the persistent calyx-lobes.

Species a genere Sarcocephalo *exclusæ.*

S. Bartlingii, Miq. = *Nauclea Bartlingii*, DC.
S. Cadamba, Kurz = *Anthocephalus indicus.*
S. madagascariensis, Baill. = *Breonia madagascariensis.*
S. macrocephalus, K. Schum. = (?) *Nauclea strigosa.*
S. gracilis, K. Schum. = (?) *Nauclea gracilis.*
S. Richardiana, Baill. = *Breonia Richardiana.*

III. BREONIA.

(Typus *B. madagascariensis.*)

Flores in capitulum globosum compacti, ebracteolati, calycibus arcte concretis. Calycis lobi 5, crassi, obtusi, ochreoleuci, pubescentes. Corolla infundibulari-tubulosa, glabra; lobi 5, imbricati. Stamina ore corollæ inserta. Stylus longe exsertus, stigmate clavato leviter bilobato. Ovarium biloculare; placentæ pendulæ; ovula in loculis 1–8, pendula. Fructus indehiscens; semina complanata, non alata.

Arbores. Folia opposita. Stipulæ subtriangulares. Pedunculi axillares, solitarii, supra medium bracteati. Bracteæ sæpe connatæ, capitulum immaturum includentes.

Breonia, *A. Rich. in Mém. Soc. Hist. Nat. Paris*, v. (1834) 290.

Cephalidium, *A. Rich. loc. cit.*

Sarcocephalus, *Baill. Adans.* xii. p. 311, partim.

Synopsis Specierum.

Folia subsessilia, nervis 12	1. *madagascariensis.*
Folia petiolata, nervis 9–11.	
Folia 19 cm. longa, 10 cm. lata. Capitula 2 cm.	2. *Boivini.*
Folia 17 cm. longa, 6 cm. lata. Capitula 12 mm.	3. *membranacea.*
Folia 14 cm. longa, 55 mm. lata. Capitula 12 mm.	4. *stipulata.*
Folia 15 cm. longa, 55 mm. lata. Capitula 7 mm.	5. *mauritiana.*
Folia 10 cm. longa, 5 cm. lata. Capitula 7 mm.	6. *Richardiana.*
Folia petiolata, nervis 7–8.	
Folia 11 cm. longa, 9 cm. lata, petiolis 3 cm.	7. *longipetiolata.*
Folia 11 cm. longa, 9 cm. lata, petiolis 15 mm.	8. *coriacea.*
Folia 10 cm. longa, 3 cm. lata, apice caudata	9. *cuspidata.*
Folia 7 cm. longa, 4 cm. lata. Capitula 4 mm.	10. *parviflora.*

1. Breonia madagascariensis, *A. Rich.*

Typi in Herbb. Paris. et Kew.

Folia 45 cm. longa, 35 cm. lata, obovata, coriacea, glabra, 12-nervia. Petioli brevissimi. Stipulæ 4 cm., carinatæ. Ramuli crassi, internodiis brevibus. Pedunculi 16 cm., complanati, sub apice bracteati. Bracteæ 3 cm., orbiculares, connatæ, rostris subulatis. Capitulum sine corollis 2 cm. Corollæ tubi 9 mm. Ovula in loculis 8.—*B. madagascariensis*, A. Rich. in Mém. Soc. Hist. Nat. v. 290. *Sarcocephalus madagascariensis*, Baill. Adans. xii. 311.

Madagascar (Chapelier, n. ?).

2. BREONIA BOIVINI, n. sp.

Typi (Boivin, n. ?) in Herbb. Paris. et Kew.

Folia 19 cm. longa, 10 cm. lata, obovata, obscure apiculata, basi attenuata, coriacea, glabra, nervis 8–10. Petioli 2 cm., crassi. Stipulæ 5 mm. Ramuli crassi, teretes, foliis in apice confertis. Pedunculi 3 cm., in medio bracteati. Florum capitulum sine corollis 2 cm. Corollæ tubi 9 mm., tenues; lobi intus hirsuti.

MADAGASCAR.—Nossibé (Boivin, n. ?).

3. BREONIA MEMBRANACEA, n. sp.

Typus in Herb. Paris.

Folia 17 cm. longa, 6 cm. lata, obovata, submembranacea, glabra, nervis 10, pallidis, nervulis tenuibus. Petioli 5 mm. Stipulæ 11 mm. Ramuli avellanei, foliis in apice confertis. Pedunculi 4 cm., graciles, sub apice bracteati. Bracteæ 4 mm., orbiculares, subacuminatæ. Capitula post anthesin 12 mm. Calycis tubi pars superior libera; lobi 5, breves, obtusi.

MADAGASCAR.

The leaves of this species are very distinct from those of other species. I have seen none with the apex uninjured.

4. BREONIA STIPULATA, n. sp.

Typus in Herb. Paris.

Arbor 7 metr. Folia 14 cm. longa, 55 mm. lata, elliptico-oblonga acuminata, nervis 10–11, nervulis reticulatis conspicuis. Petioli 15 mm. Stipulæ 15 mm., acutæ, plicatæ. Pedunculi 6 cm., complanati, glabri, sub apice bracteati. Florum capitulum sine corollis 12 mm. Corollæ tubus 8 mm. Syncarpium 25 mm. Ovula in loculis tria. Semina sæpe solitaria.

MADAGASCAR (Perville, n. ?).

Growing on the banks of rivers.

PLATE 1.—5. *Breonia stipulata.* 6. Fruit. 7. Seed.

5. BREONIA MAURITIANA, n. sp.

Typus (Commerson, n. ?) in Herb. Kew.

Folia 15 cm. longa, 55 mm. lata, oblonga, obscure acuminata, coriacea, glabra, nervis 11, nervulis reticulatis distinctis conspicuis. Petioli 15 mm. Stipulæ 1 cm. Ramuli pallidi. Pedunculi 7 cm., glabri, sub apice bracteati. Bracteæ 8 mm., orbiculares, rostris brevibus. Florum capitulum sine corollis 6 mm. Corolla glabra.

MAURITIUS.

There is only one specimen of this in the Paris Herbarium. It is

closely allied to *B. Richardiana*, from which it differs in the stouter branchlets, in the greater length of the leaves, stipules, and peduncles, and in the bracts not rupturing irregularly when the flower-heads grow too large for them. It is this specimen which has attached to it some heads of *Anthocephalus indicus* and the curious confusion about *Nauclea purpurea* and *Cephalanthus chinensis*. One of the labels is "*Cephalanthus chinensis*, Lmk. fide Herb. Planta monopetala, floribus capitatis, capitula involucro diphyllo, quam vide in icon. Commerson inter incerta Specimen unicum in herbario ... Ile de France, Herb. de Commerson sans nom."

6. Breonia Richardiana, *Hav.*

Typus (*Chapelier*, n. ?) *in Herb. Paris.*

Arbuscula. Folia 10 cm. longa, 5 cm. lata, elliptica, apice breviter et obtuse acuminata, vel obtusa, basi attenuata, coriacea, glabra, nervis 9 supra depressis, nervulis reticulatis ochreoleucis. Petioli 12 mm. Stipulæ 5 mm. Ramuli tenues pallidi, juniores 4-angulati, internodiis 4 cm. Pedunculi 25 mm., sub apice bracteolati. Bracteæ connatæ, capitulum immaturum includentes, irregulariter ruptæ. Capitula sine corollis 7 mm.—*Sarcocephalus Richardiana*, Baill. Adans. xii. 311. *Cephalidium citrifolium*, A. Rich. in Mém. Soc. Hist. Nat. v. 290.

Madagascar.

The type of Richard's *Cephalidium citrifolium* is still in the Paris Herbarium; it is only in fruit, but appears to belong to this species.

7. Breonia longipetiolata, n. sp.

Typus (*Leprieur*, *Guiane française* ?) *in Herb. Paris.*

Folia 110 mm. longa, 90 mm. lata, ovata, basi aliquanto in petiolis decurrentia, coriacea, glabra, nervis 8, patentibus. Petioli 30 mm. Ramuli juniores subangulati. Pedunculi 90 mm., tenues. Capitulum sine corollis 10 mm. Corollæ tubi 5 mm., lobi satis elongati.

Distribution (?).

The label on the specimen from which the description is taken is "Guiane française (?) M. Leprieur." The locality must therefore be considered doubtful.

8. Breonia coriacea, n. sp.

Typus (*Humblot*, n. ?) *in Herb. Kew.*

Folia 11 cm. longa, 55 mm. lata, elliptica, obtuse acuminata, valde coriacea, glabra, nervis 7 flavis. Petioli 15 mm. Stipulæ 12 mm. Ramuli avellanei, internodiis 7 mm. Pedunculi 45 mm., complanati. Capitula sine corollis 14 mm. Corollæ tubi 5 mm.

Stylus 1 cm. Calycis tubi pars superior 2 mm. Ovula in loculis sæpe 3.

MADAGASCAR.

9. BREONIA CUSPIDATA, *Hav.*

Typus (*Baron*, n. 5563) *in Herb. Kew.*

Folia 10 cm. longa, 3 cm. lata, oblanceolata, apice caudata, acuminata, basi attenuata, glabra, nervis 7. Petioli 12 mm. Stipulæ 5 mm. Internodia 4–60 mm. Pedunculi 4 cm., glabri, complanati. Bracteæ duæ, orbiculares, apiculatæ, glabræ. Capitulum sine corollis 6 mm. Corolla glabra; tubus 5 mm., rubicundus, latus. Stylus 8 mm. Calycis lobi pars superior 1 mm. Ovula in loculis sæpe solitaria.—*Nauclea cuspidata*, Baker, in Journ. Linn. Soc., Bot. xxv. (1890) 319.

MADAGASCAR (Baron, nn. 5563, 6602; Scott Elliot, n. 2214).

10. BREONIA PARVIFLORA, n. sp.

Typus (*Hildebrandt*, n. 3309) *in Herb. Kew.*

Arbor. Folia 7 cm. longa, 4 cm. lata, elliptica vel elliptico-obovata, apice obtuse acuminata, supra nitida, nervis 8 subtus pubescentibus fulvis. Petioli 15 mm. Stipulæ 3 mm. Ramuli tenues, internodiis 5-100 mm. Pedunculi 2 cm., pubescentes. Capitula sine corollis 4 mm. Corollæ tubus 4 mm., tenuis; lobi 4. Stylus 7 mm. Calycis pars superior brevis, cupularis; lobi 4. Ovula in loculis solitaria.

MADAGASCAR (Hildebrandt, n. 3309).

PLATE 1.—1. *Breonia parviflora*. 2. Flowers. 3. Stigma. 4. Ovules.

IV. CEPHALANTHUS.

(Typus *C. occidentalis.*)

Flores in capitulum globosum compacti, bracteolis filiformibus intermixtis, calycibus non concretis. Calycis tubus obovoideus; lobi 4–5, breves, obtusi, persistentes. Corolla tubuloso-infundibularis; lobi 4–5, imbricati. Stamina ore corollæ inserta. Stylus elongatus, stigmate clavato. Ovarium biloculare; ovula in loculis solitaria, ab apice loculi pendula. Fructus obovoideus, indehiscens, semina non complanata. Frutices vel arbusculæ erectæ. Folia opposita vel ternatim verticillata. Stipulæ interpetiolares, breves. Capitula terminalia vel terminalia et axillaria, rare solitaria, sæpissime paniculata.

Cephalanthus, *Linn. Sp. Pl.* ed. 1. 95.

Nauclea (partim), *Roxb. Fl. Ind.* i. 516.

Buddlea, *Spreng. Syst. Veg.* i. 431 (1825), partim.

Synopsis Specierum.

Sectio 1.

Capitula solitaria vel racemosa, terminalia, vel axillaria et terminalia. Calycis lobi distincti. Corollæ lobi ovati, basi glandulis nigris instructi. Arillus albus, fungosus. Folia nervulis speciosis reticulata.

Capitulum sine corollis 8 mm.
  Folia plus quam 2 cm. lata .... 1. *occidentalis.*
  Folia minus quam 2 cm. lata.
    Calycis lobi lineares .... 2. *angustifolius.*
    Calycis lobi ovati .... 3. *salicifolius.*
Capitulum sine corollis 5 mm. .... 4. *Sarandi.*

Sectio 2.

Capitula racemosa, terminalia. Calycis lobi distincti. Corollæ lobi oblongi. Funiculus tenuis. Folia nervulis transversis tenuibus ornata.

Corollæ tubi 6 mm. .... 5. *peruvianus.*
Corollæ tubi 3 mm. .... 6. *breviflorus.*

Sectio 3.

Pedunculi simplices solitarii. Calycis lobi distincti. Corollæ lobi breves. Arillus parvus. Folia nervulis indistinctis reticulata.

Corollæ tubi 7 mm. .... 7. *natalensis.*

1. Cephalanthus occidentalis, *Linn.*

Arbuscula. Folia 11 cm. longa, 5 cm. lata, elliptico-lanceolata, apice acuminata, basi rotundata, membranacea, glabra vel hirsuta, opposita vel ternatim verticillata, nervis 8–10, nervulis reticulatis conspicuis. Petioli 12 mm. Stipulæ 4 mm., sæpe glandulis nigris. Ramuli tenues, glabri vel pubescentes. Pedunculi 3–5 cm., simplices vel ramosi, terminales et in axillis foliorum superiorum siti. Bracteæ parvæ. Capitula sine corollis 8 mm. Corollæ tubus 5–6 mm., glaber; lobi 4 vel 5, intus sparse pubescentes, sæpissime glandulis nigris prope sinus sitis. Antheræ usque ad medios lobos pervenientes. Stylus 1 cm., tenuis. Calycis tubi pars superior 1 mm., intus pubescens; calycis lobi ovati. Receptaculum hirsutum. Bracteolæ subfiliformes. Ovula solitaria, complanata, funiculis fungosis. Semina non complanata, arillis magnis.—*C. occidentalis*, Linn. Sp. Pl. ed. 1. 95. *C. naucleoides*, DC. Prod. iv. 539; Kurz, For. Fl. Burma, ii. 68; Hook. f. Fl. Brit. Ind. iii. 24. *C. orientalis*, Roem. et Schult. Syst. iii. 105. *C. oppositifolius*, Moench, Meth. 487 (1794). *C. angustifolius*,

André, in Rev. Hort. 1889, p. 281. *C. obtusifolius*, Rafin. New Fl. Am. iii. 25. *C. acuminatus*, Rafin. loc. cit. *C. pubescens*, Rafin. loc. cit. *Nauclea tetrandra*, Roxb. Fl. Ind. i. 516.

INDIA.—Burmah (Griffith, Kew Distr. n. 3090). Assam (Clarke, nn. 37596, 38009), (Jenkins, n. 492). Cachar (Keenan). Silhet (Wallich, n. 6101). Sikhim (Hooker f.). Khasia (Hooker f.).

S.E. ASIA.—Hainan (Henry, nn. 8013, 8601). China (Fortune n. ?).

N. AMERICA.—Canada (Linden), (Macoun, n. 644). Kentucky (Short). Pennsylvania (Moser). Florida (Curtis, n. 1118 & n. 4837), (Nash). New Orleans (Drummond), (Vallé). Texas (?), (Lindheimer), (Drummond), (Heller), (Palmer). California (Hartweg, n. 1765), (Coville), (Michener), (Hooker). Mexico (Rovirosa, n. 134).

WEST INDIES.—Cuba (Wright, n. 2758).

S. AMERICA.—Brazil.

Java is generally given as a locality for this plant: the only ground for this that I can find is the plant (Zollinger, n. 1509) which was described by Moritzi as *Cephalanthus aralioides*. There is a specimen of it in the British Museum. Miquel is probably correct in determining it to be *Adina polycephala*.

2. CEPHALANTHUS ANGUSTIFOLIUS, *Lour.*

Typus in Herb. Brit. Mus.

Folia ternatim verticillata, 1 dm. longa, 15 mm. lata, oblongo-linearia, utrinque attenuata, coriacea, glabra, nervulis reticulatis conspicuis. Petioli 3 mm. Stipulæ 3 mm., rostratæ, bipartitæ, in medio interruptæ, interdum integræ. Internodia 1 cm. Pedunculi 3 cm., terminales, solitarii, ebracteati. Capitula sine corollis 8 mm. Fructus $1\frac{1}{2}$ mm. Calycis tubi pars superior $\frac{1}{2}$ mm., persistens; calycis lobi 1–2 mm., lineares hirsuti. Bracteolæ filiformes, hirsutæ. Receptaculum hirsutum.—*C. angustifolius*, Lour. Fl. Cochinch. (1790) i. 67; ed. (1793) i. 83. *C. stellatus*, Lour. loc. cit. (1790) i. 68; ed. (1793) i. 84.

COCHIN CHINA.

The authentic specimen in the British Museum is in fruit. In Wallich's Herbarium there is a specimen in flower (Wall. List, n. 6102) labelled *Cephalanthus stellatus*, Lour. (?). It seems to agree with this species. In Loureiro's description *C. angustifolius* is distinguished from *C. stellatus* by the leaves being opposite and not whorled, but this is not in the British Museum specimen.

3. CEPHALANTHUS SALICIFOLIUS, *Humb. & Bonpl.*

Folia 6 cm. longa, 9 mm. lata, linearia, acuminata, subtus sparse pubescentia, ternatim verticillata, nervis 10. Petioli 3mm. Stipulæ 2 mm. Ramuli tenues, internodiis 2 cm. Pedunculi 6 cm., terminales et axillares, sæpe bracteati. Bracteæ parvæ.

Capitula sine corollis 8 mm. Corolla glabra, tubo 5 mm., lobis sæpissime 4. Stylus 14 mm. Calyx dense hirsutus, parte superiore 1 mm., non dilatata; lobi breves, sæpe glandulis nigris obsiti. Semina arillis magnis ornata.—*C. salicifolius*, Humb. et Bonpl. Pl. Eq. ii. 63.

MEXICO.—Manzonvilla Bay (Barclay). Loc. incert.; (Beechey), (Gurgensen, n. 160). Prov. Puebla (Andrieux, n. 331). Cordillera Morelia, alt. 3600 ft. (Galeotti, n. 2593).

4. CEPHALANTHUS SARANDI, *Cham. et Schlecht.*

Frutex. Folia 6 cm. longa, 18 mm. lata, lineari-lanceolata, ternatim verticillata, glabra, nervis 5 obliquis. Petioli 4 mm., pubescentes. Stipulæ 1 mm., integræ vel lobatæ. Ramuli fuliginei, internodiis 2 cm. Capitula racemosa, terminalia et axillaria. Pedunculi graciles, sæpe ebracteolati. Capitula sine corollis 5 mm. Corollæ tubus 3 mm. Stylus 6 mm. Calycis tubi pars superior 1 mm., glabra, breviter lobata. Semina arillis magnis ornata. Receptaculum hirsutum.—*C. Sarandi*, Cham. et Schlecht. in Linnæa, ii. (1827) 610. *C. glabratus*, K. Schum. in Mart. Fl. Brasil. vi. 129. *Buddlea glabrata*, Spreng. Syst. Veg. i. 431 (1825).

S. AMERICA.—Brazil (? type specimen). Paraguay (Balansa, n. 1993). Uruguay (Auguste de Saint-Hilaire, n. 2364), (Gibert, n. 1399), (Lorentz). Monte Video (Capt. King), (Gibert, nn. 32, 35, 38). Buenos Ayres (Fox, n. 262). Rio Janeiro (Glaziou, n. 12044). La Plata (Tweedie, n. 126).

A spreading shrub, common on the banks of rivers. Flowers scented.

5. CEPHALANTHUS PERUVIANUS, *Spruce.*

Typi (*Spruce*, n. 4910) *in Herb. Kew.*

Arbor, 6 m. Folia 17 cm. longa, 7 cm. lata, elliptica, apice breviter acuminata, basi attenuata, submembranacea, glabra, ternatim verticillata, nervis 10. Petioli 3 cm. Stipulæ 1 cm., hirsutæ, triangulares. Inflorescentia terminalis, pseudo-racemosa. Pedunculi hirsuti. Capitula sine corollis 7 mm. Corollæ tubus 6 mm.; lobi 5, oblongi, reflexi. Stylus 9 mm.; stigma $1\frac{1}{2}$ mm. Calycis tubus 2 mm., cupularis, hirsutus, parte superiore membranacea, limbo undulato. Ovula funiculis tenuibus. Bracteolæ filiformes. —*C. peruvianus*, Spruce, MS., Pl. exsicc. n. 4910; K. Schum. in Mart. Fl. Brasil. vi. 6. p. 130.

PERU.—Tarapoto (Spruce, n. 4910).

6. Cephalanthus breviflorus, *Spruce.*

Typi (*Spruce* n. 4175) *in Herb. Kew.*

Arbor quoad folia et inflorescentiam. *C. peruviano* similis. Capitula sine corollis 6 mm. Corollæ tubus 3 mm.; lobi 5, oblongi. Stylus 6 mm. Calycis tubus 2 mm., cupularis, quam in *C. peruviano* angustior, hirsutus, parte superiore membranacea, limbo undulato.—*C. breviflorus*, Spruce, MS. Pl. exsicc.; K. Schum. in Mart. Fl. Brasil. vi. 6. 130.

Peru.—Tarapoto (Spruce, nn. 4129, 4175).

7. Cephalanthus natalensis, *Oliver.*

Typus in Herb. Kew.

Frutex 2 mm. Folia 4 cm. longa, 25 mm. lata, ovato-lanceolata, coriacea, glabra, nervis 4–6. Petioli 5 mm., complanati, glabri vel hirsuti. Stipulæ 3 mm., pubescentes, basi latæ, apice subulatæ. Ramuli teretes, pubescentes. Pedunculi 1 cm., solitarii, terminales, hirsuti. Capitula sine corollis 6 mm. Corollæ tubus 7 mm., glaber; lobi 4–5, subvalvati, intus hirsuti. Antheræ fere ad apices corollæ lobi pervenientes. Stylus 14 mm. Calyx extra glaber, parte superiore tubulari breviter lobatâ intus hirsutâ. Bracteolæ filiformes, hirsutæ. Fructus 2 mm., carnosi, indehiscentes, superne hirsuti. Semina arillis parvis aucta.—*C. natalensis*, Oliver, in Hook. Ic. Pl. t. 1331.

S. Africa.—Natal, loc. incert. (Gerard, n. 1495); Biggarsberg (Medley Wood, n. 4760, alt. 4000 ft.); Drakensberg (Rehmann, n. 6996). Transvaal; Barberton (Galpin, n. 534); loc. incert. (Atherstone).

The fruit is edible.

Species a genere Cephalantho *exclusæ.*

C. africanus, Reich. ex DC. Prod. iv. 346=*Mitragyna africana.*

C. chinensis, Lam. Encycl.=*Adina globiflora.*

C. montanus, Lour., has alternate leaves.

C. orientalis, Linn. Sp. Pl.=*Nauclea orientalis.*

C. orientalis, Blume, Cat. Gew. Buitenz. 38=*Nauclea lanceolata.*

C. pilulifer, Lam. Encycl. i. 679=*Adina globiflora.*

C. procumbens, Lour., has alternate leaves.

C. spathelliferus, Baker in Journ. Bot. xx. (1882) 137=*Adina microcephala.*

Species dubia.

C. piluliflorus, Willd. Herb. ex Roem. et Schult. Syst. iii. 525.

V. Adina.

(Typus *A. globiflora.*)

Flores in capitulum globosum compacti, bracteolis filiformibus intermixtis, calycibus non concretis. Calycis tubus prismaticus; lobi 0 v. 5, persistentes, sæpissime breves. Corollæ tubus tenuis; lobi 5, ovati, imbricati, vel pseudo-valvati. Stamina 5, ore corollæ inserta; antheræ breves, oblongæ. Stylus elongatus, tenuis, stigmate clavato. Ovarium biloculare, placentis pendulis; ovula complanata, deorsum imbricata. Fructus 2-coccus; cocci integri vel 2-partiti, ab axe secedentes; axis persistens sæpe calycis lobis stellatim patentibus coronatus. Semina complanata, elongata; testa alata; ala superior sæpe bicornuta, inferior acuminata.

Arbores vel frutices. Folia opposita. Stipulæ interpetiolares, parvæ, caducæ, integræ vel bifidæ. Pedunculi terminales vel axillares, simplices vel ramosi. Capitula parva.

Adina, *Salisb. Parad. Londin.* p. 115.

Nauclea, *Linn. et auct. partim.*

Synopsis Specierum.

Sectio 1.

Ovula in loculis 2–4. Folia 3–4nim verticillata.

Pedunculi axillares, solitarii, simplices .. 1. *microcephala.*

Sectio 2.

Ovula in loculis numerosa. Folia opposita.

Stipulæ bifidæ.

Inflorescentia terminalis.

Capitula racemosa................ 2. *racemosa.*

Capitula solitaria .... 3. *rubella.*

Inflorescentia axillaris.

Corollæ glabræ .... 4. *globiflora.*

Corollæ pubescentes.............. 5. *multifolia.*

Capitula in pedunculo communi terna.. 6. *rubescens.*

Stipulæ integræ.

Inflorescentia terminalis, composita.

Calycis limbus lobatus .... 7. *polycephala.*

Calycis limbus integer .... 8. *oligocephala.*

Pedunculi ternati, axillares.......... 9. *cordifolia.*

1. Adina microcephala, *Hiern.*

Arbor. Folia 3–4nim verticillata, 18 cm. longa, 5 cm. lata, oblongo-linearia, obtusa, utrinque attenuata, coriacea, glabra,

nervis 20. Petioli 2 cm. Stipulæ subtriangulares. Ramuli robusti. Gemmæ nitentes. Pedunculi solitarii, axillares, 6 cm., complanati, supra medium bracteati. Bracteæ 1 cm., sæpe connatæ, suborbiculares, sæpe breviter rostratæ. Capitula sine corollis 8–14 mm. Corollæ tubus 5 mm., extra pubescens; lobi 5, lineares, subimbricati. Stamina ore corollæ inserta; antheræ usque ad medios lobos pervenientes. Stylus 11 mm. Stigma clavatum, parvum. Receptaculum hirsutum. Bracteolæ anguste spathulato-lineares. Calycis tubi pars superior anguste tubulosa; lobi 5, lineares, extra hirsuti. Ovula in loculis 2–4, complanata, pendula.—*A. microcephala*, Hiern, in Oliver, Fl. Trop. Afr. iii. 40. *A. Galpini*, Oliver, in Hook. Ic. Pl. t. 2386. *A. spathellifera*, Oliver, loc. cit. *A. lasiantha*, K. Schum. in Engl. Pfl. Ost-Afr., C. (p. 378). *Cephalanthus spathelliferus*, Baker, in [Trimen] Journ. Bot. 1882, p. 137. *Cephalidium verticillatum*, Boivin, fide Baill. in Adans. xii. 314. *Nauclea microcephala*, Del. Cantor. P. Mer. p. 67, n. 54 (1826). *N. microcephala*, DC. Prod. v. 345. *N. verticillata*, Baill. in Adans. xii. 314.

Var. *α*. Folia 18 cm. longa, 5 cm. lata. Calycis lobi $\frac{1}{2}$–2 mm.
Var. *β*. Folia 16 cm. longa, 2 cm. lata. Calycis lobi 2 mm.
Var. *γ*. Folia 14 cm. longa, 2 cm. lata. Calycis lobi $\frac{1}{2}$ mm.

N. Trop. Africa.—Nubia (Figari, n. ?). Dar-Fertit (Schweinfurth, n. 288).

S. Trop. Africa.—Angola (Welwitsch, n. 3029); Mossamedes (Welwitsch, n. 3028). Nyasaland (Buchanan, n. 6=*Adina lasiantha*, K. Schum.); Shiré Highlands (Buchanan, n. 44)—publ. Schweinf. Series, iii. 238.

S. Africa.—Swaziland (alt. 2000 ft., Galpin, n. 1213=*Adina Galpini*, Ic. Plant. 2386).

Madagascar.—(Baron, n. 86=*Cephalanthus spathelliferus*, Baker, in Journ. Bot. xx. 1882, p. 137); Central Madagascar (Baron, n. 4550), (Greve, n. 103).

The wood is hard and said to resemble teak. The plant possesses some of the characters of *Breonia*, some of *Cephalanthus*, and some of *Adina*. I have not seen the fruit; it may prove to be indehiscent. Although there is much variation in the leaves, peduncles, bracts, and especially in the calyx-lobes, I have been unable to group the specimens into distinct species.

2. Adina racemosa, *Miq.*

Typi in Herb. Kew. etc.

Arbor. Folia 11 cm. longa, 6 cm. lata, ovata, acuminata, basi

inæquilateralia, rotundata, supra glabra, nervis 8 subtus pubescentibus prominentibus ferrugineis. Petioli 3–6 cm., tenues. Stipulæ bilobæ, lobis rotundatis. Ramuli castanei, internodiis 15 mm. Inflorescentia terminalis, pseudo-racemosa. Pedunculi 25 mm., tenues, pubescentes, sub apice bracteati. Bracteæ minutæ, 2 mm., caducæ. Calycis lobi ovati, 1 mm., pubescentes, axem persistentem summum coronantes. Corollæ tubus 5 mm., pubescens; lobi 5, subvalvati, intus et extra pubescentes. Stamina fauce corollæ inserta, antheris apiculatis. Stylus 8 mm.; stigma parvum, subglobosum. Cocci 5 mm. Receptaculum hirsutum. Bracteolæ anguste spathulatæ.—*A. racemosa*, Miq. Ann. Mus. Lugd.-Bat. iv. 184. *Nauclea racemosa,* Sieb. et Zucc. in Abh. Akad. Muenc. iv. (1846) 178.

CHINA.—Kwangtung (Ford, n. 292); Ichang (Henry, n. 1557).

JAPAN (Oldham, n. 513, Zuccarini, Burger, De Vriese).

3. ADINA RUBELLA, *Hance.*

Folia 5 cm. longa, 2 cm. lata, lanceolata, sessilia, supra glabra, nervis 6 obliquis subtus pubescentibus. Stipulæ bifidæ, lobis linearibus. Ramuli tenues, rubicundi, internodiis 15 mm. Pedunculi 2 cm., tenues, solitarii, terminales, pubescentes. Capitula sine corollis 6 mm. Calycis lobi 1½ mm., lineares, coccis delapsis, summum axem persistentem coronantes. Corollæ tubus 3 mm., sparse hirsutus. Antheræ non apiculatæ. Stylus 8 mm. Stigma globosum. Ovula in loculis 3–4. Cocci 4 mm. Seminum alæ parvæ, subulatæ. Receptaculum subglabrum. Bracteolæ filiformes.—*A. rubella*, Hance in Journ. Bot. vi. (1868) 114.

CHINA.—Canton (Hance, n. 11229); Nan-lo (Henry); Ichang (Henry).

4. ADINA GLOBIFLORA, *Salisb.*

Frutex. Folia 7 cm. longa, 2 cm. lata, oblanceolata, acuminata, membranacea, glabra, nervis 8–10. Petioli 5–10 mm. Stipulæ bifidæ. Ramuli tenues, internodiis 1–4 cm. Pedunculi 4 cm., tenues, solitarii, axillares vel pseudo-terminales, infra medium bracteati. Bracteæ parvæ. Capitulum sine corollis 5 mm. Calycis lobi oblongi, subglabri, summum axem persistentem coronantes. Corollæ tubi 3 mm., glabri; lobi 5, imbricati. Antheræ non apiculatæ. Stylus 6 mm.; stigma ovoideum. Cocci 2 mm., sparse hirsuti. Seminum alæ parvæ, subulatæ. Receptaculum hirsutum. Bracteolæ filiformes.—*A. globiflora*, Salisb. Parad. Londin. p. 115 (1807); DC. Prod. iv. 349. *A. peduncu-*

laris, DC. Prod. loc. cit. *A. globifera* (by error in quoting *A. globosa*), Baill. in Adans. xii. 314. *A. pedunculata*, DC. in Benth. Fl. Hongk. 146. *A. pilulifera*, Franch. ex Drake de Castello in Journal de Botanique, ix. (1895) 207. *Nauclea* sp., Linn. MS. in Herb. Banks. *N. Adina*, Smith, in Rees's Cyclop. *N. adinoides*, Lindl. Bot. Reg. xi. 895. *Cephalanthus chinensis*, Lam. Encycl. i. 678. *C. pilulifer*, Lam. Encycl. i. 678.

CHINA.—(Fortune, n. 119; Ford, n. 314). Hongkong (Hance, n. 520; Wright, n. 246; Urquhart). Hainan (Henry, n. 8570).

TONQUIN (Balansa, n. 636).

5. ADINA MULTIFOLIA, n. sp.

Typus (*Vidal*, n. 2948) *in Herb. Kew.*

Folia 65 mm. longa, 30 mm. lata, ovata, obtuse acuminata, chartacea, glabra, nervis 7. Petioli 7 mm., tenues. Stipulæ 4 mm. Ramuli tenues, castanei. Pedunculi 3 cm., tenues, pubescentes, solitarii, axillares, supra medium bracteati. Bracteæ 3 mm., acutæ, basi connatæ. Capitula 18 mm. Calyx pubescens, parte superiore intus hirsuta; lobi brevissimi, obtusi. Corollæ tubus 5 mm., extus pubescens; lobi sæpe 6, extra et intus pubescentes. Stamina fauce corollæ inserta; filamenta brevia; antheræ lanceolatæ vix usque ad medios lobos pervenientes, basi subsetosæ. Stylus 8 mm.; stigma subglobosum. Ovula in loculis 5–6.

INS. PHILIPPINÆ.—Luzon, Prov. Tayabas (Vidal, n. 2948).

6. ADINA RUBESCENS, *Hemsl.*

Typus (*Wray*, n. 539) *in Herb. Kew.*

Arbor. Folia 9 cm. longa, 45 mm. lata, ovata, acuminata, subcoriacea, supra glabra, nervis 9 subtus pubescentibus rubicundis. Petioli 7 mm. Stipulæ 2 mm., bifidæ. Ramuli pallidi, juniores subrubicundi. Capitula axillaria, in pedunculo commune terna; pedunculi 2 cm., tenues, rubicundi, pubescentes. Capitula 1 cm. Calyx pubescens, parte superiore brevissimâ; lobi $\frac{1}{2}$ mm., oblongi. Corollæ tubus 2 mm., extra hirsutus; lobi subvalvati. Stamina ore corollæ inserta; antheræ ultra medios lobos pervenientes, basi subsetosæ. Stylus 4 mm.; stigma globosum. Ovula in loculis 6–7. Receptaculum hirsutum; bracteolæ lineares, complanatæ, pubescentes.—*A. rubescens*, Hemsl. in Journ. Bot. xxv. (1887) p. 204.

MALAY PENINSULA.—Perak; Ayer Larut (Wray, n. 539). Penang (Curtis, n. 369).

7. ADINA POLYCEPHALA, *Benth.*

Typus (*Wall. List*, n. 6100).

Folia 11 cm. longa, 4 cm. lata, elongato-lanceolata vel elliptico-oblanceolata, apice caudata, utrinque acuminata, glabra, in nervorum axillis hirsuta, nervis 8–12. Petioli 1 cm. Ramuli avellanei, internodiis 1 cm. Inflorescentia terminalis, paniculata. Capitula sine corollis 6 mm. Pedunculi tenues, pubescentes; bracteæ 4 mm., lineares. Calycis lobi 1 mm., oblongi, obtusi, summum axem persistentem coronantes. Corollæ tubi 3 mm., glabri; lobi 4–5, imbricati. Stamina ore corollæ inserta, antheræ usque ad medios lobos pervenientes. Stylus 7 mm.; stigma clavatum. Cocci $2\frac{1}{2}$ mm., superne hirsuti. Receptaculum hirsutum. Bracteolæ filiformes. Semina vix alata.—*A. polycephala*, Benth. Fl. Hongk. p. 146; Miq. Ann. Mus. Lugd.-Bat. iv. 183. *A. aralioides*, Benth. et Hook. f. Gen. Pl. ii. 30. *Nauclea polycephala*, Wall. List, n. 6100; G. Don, Gen. Syst. iii. 467. *N. microcephala*, Wall. MS. *N. capitellata*, Voigt, Hort. Calc. 375. *N. trichotoma*, Zoll. Verz. Ind. Archip. p. 61 (1846). *N. aralioides*, Miq. Fl. Ind. Bat. ii. 344. *Cephalanthus aralioides*, Zoll. loc. cit.

Var. *α*. Folia 11 cm. longa, 4 cm. lata, elongato-lanceolata, apice caudata, acuminata. Petioli 1 cm. Capitulum minus. (Khasia to Moulmein.)

Var. *β*. Folia 18 cm. longa, 7 cm. lata, elliptico-oblanceolata. Petioli 1 cm. Capitulum majus. (Mergui, Sumatra, Java.)

Var. *γ*. Folia 18 cm. longa, 7 cm. lata, elliptico-elongata, coriacea. Petioli 25 mm. (Cambodia.)

INDIA.—Khasia (Griffith, n. 2751); Silhet (Wall. List, n. 6100; Cole, n. ?); Chittagong (Hook. f. et T. Th.).

BURMA.—Moulmein (alt. 4000 ft., Lobb, n. ?); Mergui (Griffith, n. ?).

S.E. ASIA.—Cambodia (Pierre, n. 1226). Cochin China (Pierre, n. 3159).

MALASIA.—Sumatra (Teysmann, n. ?). Java (Zollinger, 613).

PLATE 4.—25. Flower. 26. Bracteole. 27. Calyx-lobe. 28. Stigma. 29. Fruit. 30. Section of ovary. 31. Seed.

8. ADINA OLIGOCEPHALA, n. sp.

Typus (*Griffith, Kew Distr.* n. 2751).

Folia 10 cm. longa, 4 cm. lata, elliptico-oblanceolata, apicibus caudatis 12 mm. longis, basi attenuata, glabra, in plantis exsiccatis umbrina, nervis 6. Petioli 1 cm. Stipulæ 8 mm., obtusæ,

integræ, basi pubescentes. Ramuli avellanei, internodiis 5–20 mm. Inflorescentia terminalis, composita, capitulis 4 vel 5; pedunculi sub apice pubescentes, fere ad basin bracteati; bracteæ 4 mm. lanceolatæ, basi connatæ, interdum apice bifidæ. Capitula sine corollis 6 mm. Calycis tubi pars superior $1\frac{1}{2}$ mm., cupularis, extra sparse hirsuta, intus glabra castanea, limbo integro, ab axi persistente secedente. Corollæ tubus 4 mm., glaber; lobi 5, imbricati. Ovula numerosa, deorsum imbricata. Cocci 4 mm. Seminum alæ latæ. Receptaculum hirsutum. Bracteolæ paucæ vel obscuræ.

India.—Khasia (Griffith, n. 2751).

9. Adina cordifolia, *Hook. f.*

Arbor. Folia 19 cm. longa, 19 cm. lata, orbicularia, apice acuminata, basi cordata, supra sparse hirsuta, subtus hirsuta, nervis 8 tribus infimus approximatis, nervulis transversis parallelis. Petioli 7 cm. Stipulæ 15 mm., ovato-oblongæ, hirsutæ. Ramuli robusti, pubescentes, internodiis 5–20 mm. Pedunculi 3 cm., tenues, axillares, tres vel quatuor in planitie axiali orti, sub apice bracteati. Bracteæ $1\frac{1}{2}$ mm., duæ subulatæ, duæ subovatæ. Capitula sine corollis 6 mm. Calycis lobi 1 mm., lineares, pubescentes, ab axi persistente secedentes. Corollæ tubus 6 mm., pubescens; lobi 5. Stamina fauce corollæ inserta; antheræ oblongæ obtusæ, vix usque ad medios lobos pervenientes. Stylus 11 mm.; stigma subglobosum. Cocci 4 mm., hirsuti, decidui. Receptaculum hirsutum. Bracteolæ spathulato-lineares.—*A. cordifolia*, Hook. f. in Benth. et Hook. f. Gen. Plant. ii. 30, & in Fl. Brit. Ind. iii. 24; Beddome, Fl. Sylv. t. 33, & Anal. Gen. t. 29. fig. 2. *Nauclea cordifolia*, Willd. Sp. Pl., Roxb. Pl. Cor. i. 40, t. 53, & Fl. Ind. i. 514; Wight & Arn. Prod. 391; Kurz, For. Fl. Burma, ii. 66; Dalz. & Gibs. Bomb. Fl. 118.

India.—Ceylon (Thwaites, n. 1660). Canara (herb. Hohenacker, n. 631). Carnatic (Thomson, n.?). Oudh (Brandis, n.?). Chota Nagpur (alt. 2000 ft., Clarke, n. 20707). Palagautchery (herb. Wight, n. 1299). Gakuk Tank (Ritchie, n. 1771). Behar (alt. 2000 ft., Hook. f.; Clarke, n. 24898). Sikkim (Hook. f.). Kumaon (Winterbottom, n. 1).

S.E. Asia.—Cambodia (Godefroy-Lebeuf, Pierre, nn. 586, 1228). Cochin China (Pierre, n. 1707).

Species a genere Adinâ *exclusæ.*

A. Griffithi, Hook. f. Fl. Brit. Ind. iii. 24=*Nauclea Griffithi.*
A. philippinensis, Vidal, Fl. Vasc. Filip. 148=*Nauclea philippinensis.*
A. rubrostipulacea, K. Schum. in Engl. Pfl. Ost-Afr. 378=*Mitragyna rubrostipulacea.*
A. sessilifolia, Hook. f. Fl. Brit. Ind. iii. 24=*Nauclea sessilifolia.*

VI. Nauclea.

(*Typus nullus.*)

Flores in capitulum globosum compacti, ebracteolati, vel bracteolis glabris setiformibus intermixti. Calycis tubus prismaticus; lobi 5, decidui, filiformes, apice sæpissime clavati vel spathulati, præfloratione arcte compacti, valvati. Corollæ tubus infundibularis; lobi 5, imbricati. Stamina 5, in tubo corollæ inclusa; antheræ oblongæ vel lineares. Stylus elongatus, crassiusculus; stigma globosum. Ovarium biloculare, placentis pendulis; ovula complanata, deorsum imbricata. Fructus 2-coccus; cocci sæpe ab axe persistente secedentes; axis persistens, calycis parte superiore nunquam coronatus. Semina complanata, elongata; testa alata; ala superior bicornuta, inferior acuminata. Frutices vel arbores. Folia opposita, nervis secundariis sæpissime paucis. Stipulæ complanatæ, deciduæ, integræ, interpetiolares. Pedunculi simplices, terminales, solitarii vel ternati, sub apice bracteati, modo teretes verrucosi superne incrassati, modo graciles complanati. Bracteæ sæpe amplæ, caducæ.

Nauclea, *Linn. Sp. Pl.* ed. 2, 243; *Roxb. Pl. Corom.* i. 40; *Korth. Obs. Naucl. Ind.* p. 18; *Benth. et Hook. f. Gen. Pl.* ii. 31.

None of the plants called *Nauclea* by Linnæus are now in this genus, though there is no doubt that he would have called those in it *Nauclea* if he had seen them. The oldest species now in the genus is *Nauclea purpurea*, Roxb.; but this plant is not very typical of the genus as it at present stands. It was Korthals who first gave the genus approximately its present limits, though he united with it *Adina* and *Breonia*, neither of which genera he had, however, seen.

Synopsis Specierum.

Sectio 1.

Pedunculus fere medio bracteatus. Bracteæ parvæ. Bracteolæ subconicæ.

Calycis lobi purpurei.
- Ovula in loculis solitari .... 1. *zeylanica.*
- Ovula in loculis numerosa.
  - Pedunculi 1-nodosi .... 2. *purpurea.*
  - Pedunculi 2-nodosi .... 3. *Griffithii.*

Calycis lobi non purpurei.
- Folia subsessilia, obtusa .... 4. *sessilifolia.*
- Folia petiolata, apice longe caudata.
  - 5–6-nervia .... 5. *gracilis.*
  - 4-nervia .... 6. *philippinensis.*

Sectio 2.

Pedunculus sub apice bracteatus. Bracteæ magnæ, caducæ. Bracteolæ nullæ. Calycis loborum apices parvi, non flavi.

- Calyces concreti .... 7. *strigosa.*
- Calyces non concreti.
  - Folia apice obtusa.
    - 6-nervia .... 8. *nitida.*
    - 11-nervia .... 9. *celebica.*
  - Folia apice longe caudata.
    - 5-nervia .... 10. *lanceolata.*
    - 7-nervia .... 11. *tenuis.*
  - Folia lineares.
    - Calycis lobi spathulati .... 12. *angustifolia.*
    - Calycis lobi subulati .... 13. *Chalmersii.*

Sectio 3.

Pedunculus sub apice bracteolatus. Calycis lobi clavati, speciosi, pubescentes.

- Folia 45 cm. longa, 36 cm. lata ...... 14. *cyclophylla.*
- Folia 22 cm. longa, 10 cm. lata ...... 15. *media.*
- Folia 12 cm. longa, 6 cm. lata ...... 16. *Forsterii.*

Sectio 4.

Pedunculus sub apice bracteolatus. Bracteæ magnæ, caducæ. Bracteolæ nullæ vel setosæ. Calycis lobi apice glabri, flavi.

- Antheræ usque ad summum tubum corollæ non pervenientes.
  - Calycis loborum pars persistens subulato-lanceolata. 17. *cyrtopoda.*

Calycis loborum pars persistens brevis, subtruncata.
Folia 10–12-nervia .... 18. *peduncularis.*
Folia 8–10-nervia .... 19. *purpurascens.*
Antheræ usque ad summum tubum corollæ pervenientes.
Calycis loborum partes persistentes lanceolatæ, acutæ.
Corollæ lobi extra glabri.
Bracteæ subpersistentes .... 20. *pallida.*
Bracteæ caducæ .... 21. *nicobarica.*
Corollæ lobi extra pubescentes.
Pedunculi tenues.
Petioli nigri; ramuli pallidi .. 22. *synkorynes.*
Petioli ramulis concolorati.
Folia glabra .... 23. *excelsa.*
Folia pubescentia .... 24. *mollis.*
Pedunculi apices versus incrassati. 25. *obtusa.*
Calycis loborum partes persistentes subtruncatæ.
Folia oblonga .... 26. *Bartlingii.*
Folia orbicularia .... 27. *reticulata.*
Calycis lobi ignoti.
Folia 15 cm. Stipulæ lineares .... 28. *moluccana.*
Folia 15 cm. Stipulæ oblongæ .... 29. *morindæfolia.*
Folia 9 cm. Petioli tenues ...... 30. *fagifolia.*

1. Nauclea zeylanica, *Hook. f.*

Typus in Herb. Kew.

Arbor. Folia 11 cm. longa, 36 mm. lata, elliptico-lanceolata, obtuse acuminata, basi attenuata, glabra, nervis 6–8. Petioli 8 mm. Stipulæ 8 mm., oblongæ. Pedunculi 3 cm., tenues, ternati, fere medio bracteati. Bracteæ 2 mm. Capitula sine corollis 8 mm. Corollæ tubus 4 mm., superne hirsutus; lobi extra hirsuti. Antheræ usque ad summum tubum pervenientes. Stylus 8 mm.; stigma subglobosum. Calycis lobi 1 mm., oblongi, subspathulati, sparse hirsuti, subpersistentes. Ovarium biloculare; ovula solitaria, pendula. Receptaculum hirsutum. Bracteolæ nullæ.—*N. zeylanica*, Hook. f. Fl. Brit. Ind. iii. 26. *N. peduncularis*, Thwaites, Enum. Pl. Zeyl. p. 137.

Ceylon (Gardner, n. 1317; Thwaites, n. 2820).

This species differs from all others of the genus in the solitary ovules and persistent calyx-lobes, but it seems most nearly allied to *Nauclea purpurea*. I have not seen its fruit.

2. Nauclea purpurea, *Roxb.*

Arbuscula. Folia 15 cm. longa, 6 cm. lata, elliptica vel

elliptico-lanceolata, utrinque acuminata, membranacea, glabra, nervis 8–10. Petioli 1 cm., in plantis exsiccatis nigri. Internodia 2 cm. Pedunculi 3–4 cm., solitarii, prope medium bracteati, teretes superne incrassati. Bracteæ caducissimæ. Corollæ tubus 6 mm.; lobi extra sparse hirsuti. Antheræ usque ad summum corollæ tubum pervenientes. Stylus 12 mm. Calycis loborum partes deciduæ 4 mm., hirsutæ, purpureæ, partes persistentes hirsutæ, fulvæ. Calycis tubus subglaber. Receptaculum hirsutum. Bracteolæ conicæ. Ovula in loculis numerosa. Fructuum axes persistentes.—*N. purpurea*, Roxb. Pl. Coromand. i. 41, t. 54, et Fl. Ind. i. 515; Wight et Arn. Prod. 391; Bedd. Fl. Sylv. 129, et Ic. Pl. Ind. Or. t. 19; Hook. f. Fl. Brit. Ind. iii. 26.

India.—Kanara: Kanara Ghâts, alt. 1500 ft. (Beddome), North Kanara (Talbot, n. 1601).

3. Nauclea Griffithii, *Hav.*

Typus (*Griffith, Kew Dist.* 2753).

Arbuscula. Folia 13 cm. longa, 7 cm. lata, elliptica, abrupte breviter acuminata vel obtusa, coriacea, glabra, nervis 7. Petioli 8 mm. Internodia 10–25 mm. Pedunculi 25 mm., solitarii vel ternati, prope medium bracteati, nodis duobus. Bracteæ caducissimæ. Capitulum sine corollis 9 mm. Corolla glabra; tubus 8 mm. Stylus 14 mm.; stigma globosum. Antheræ usque ad summum tubum pervenientes. Calycis lobi hirsuti, partibus deciduis clavatis purpureis; tubus subglaber. Ovula in loculis numerosa. Receptaculum subglabrum. Bracteolæ glabræ, conicæ, flavæ.—*Adina Griffithii*, Hook. f. Fl. Brit. Ind. iii. 24.

India.—Khasia (Griffith, Kew Dist. n. 2753), alt. 3000 ft. (Hooker f. et T. Thomson).

Sir Joseph Hooker placed this plant in *Adina* on account of the bracteoles, but it is closely allied to *N. purpurea*, and may even be a variety of it.

4. Nauclea sessilifolia, *Roxb.*

Arbuscula, 10-metralis. Folia 14 cm. longa, 7 cm. lata, oblonga vel ovata, apice obtusa, basi subcordata, subsessilia, maxime coriacea, glabra, nervis 8–9. Stipulæ 15 mm., oblongæ, glabræ. Ramuli robusti, pallidi, internodiis 15 mm. Pedunculi 4 cm., robusti, solitarii vel ternati, prope medium bracteati. Corolla villosa. Calycis loborum partes deciduæ 5 mm., clavatæ, villosæ, apice conicæ, glabræ. Capitulum fructuum 15 mm. Cocci 5 mm., fulvi, superne pubescentes. Axis persistens. Receptaculum sparse hirsutum. Bracteolæ 1 mm., glabræ, sub-

ulatæ.—*N. sessilifolia*, Roxb. Fl. Ind. i. 515; Kurz, For. Fl. Burma, ii. 65. *N. ovalifolia*, Roxb. Fl. Ind. i. 516. *N. sericea*, Wall. List, n. 6095; G. Don, Gen. Syst. iii. 467. *Adina sessilifolia*, Hook. f. in Benth. et Hook. f. Gen. Pl. ii. 30, et Fl. Brit. Ind. iii. 24.

INDIA.—Cachar (Keenan). Chittagong (Clarke, n. 19922), (Hooker f. et Thomson). Pegu, Rangoon (M'Clelland).

S.E. ASIA.—Cochin China: Prov. Chau Doc (Pierre, n. 3162).

This species is in many respects unlike any other species of *Nauclea* or *Adina*, but seems to me to go better with *Nauclea* than with *Adina*.

5. NAUCLEA GRACILIS, *Vidal*.

Typus (*Cuming*, n. 835) *in Herb. Kew.*

Folia 8 cm. longa, 22 mm. lata, elliptico-lanceolata, apice longe caudata, basi attenuata, glabra, nervis 5. Petioli 3 mm. Internodia 2–6 cm. Pedunculi 25 mm., tenues, prope medium bracteati. Bracteæ parvæ, 1 mm. Corollæ tubus 4¼ mm., superne hirsutus; lobi 5, extra hirsuti. Antheræ oblongæ, obtusæ, usque ad basin loborum pervenientes. Stylus 7 mm.; stigma globosum. Calycis loborum partes deciduæ 1⅓ mm., clavatæ, partes persistentes 1 mm., lineari-lanceolatæ, glabræ; tubus 1 mm. Receptaculum sparse hirsutum. Bracteolæ 1 mm., subulatæ, glabræ.—*N. gracilis*, Vidal, Phan. Cuming. Philip. p. 176.

INS. PHILIPPINÆ.—Luzon: Prov. Albany (Cuming, n. 835).

6. NAUCLEA PHILIPPINENSIS, *Hav.*

Typus (*Vidal*, n. 371) *in Herb. Kew.*

Folia 10 cm. longa, 4 cm. lata, oblanceolata, apice caudata, basi attenuata, glabra, nervis 4 obliquis. Petioli 1 cm., tenues. Pedunculi 25 mm., tenues, solitarii vel ternati, prope medium bracteati. Corollæ tubus 4 mm., glaber, lobi extra pubescentes. Antheræ oblongæ obtusæ, usque ad basin loborum pervenientes. Stylus 1 cm.; stigma globosum. Calycis lobi 1 mm., subpersistentes, apice clavati; tubus ½ mm. Receptaculum hirsutum. Bracteolæ subulatæ, glabræ.—*Adina philippinensis*, Vidal, Fl. Vasc. Filip. 148. *A. polycephala*, Vidal, Synops. t. 56.

INS. PHILIPPINÆ.—Luzon (Vidal, n. 371).

7. NAUCLEA STRIGOSA, *Korth.*

Typus in Herb. Leiden.

Frutex. Folia 11 cm. longa, 35 mm. lata, in apicibus ramulorum conferta, oblonga vel oblanceolata, acuminata, supra glabra,

subtus pubescentia, nervis 7–11. Petioli 1 cm. Stipulæ 15 mm., oblongæ, sparse hirsutæ. Pedunculi 25 mm., solitarii, pubescentes, sub apice bracteati. Bracteæ 1 cm., caducæ. Corollæ tubus 11 mm., glaber; lobi extra pubescentes. Antheræ usque ad basin loborum pervenientes. Stigma globosum. Calycis loborum partes deciduæ 3 mm., spathulatæ, partes persistentes lanceolatæ; calycis tubi pars superior 1½ mm., sparse hirsuta, pars inferior arcte concreta. Fructus in syncarpium globosum connati, apice elevato-conici. Endocarpium superne incrassatum. Semina rugosa, longe alata.—*N. strigosa*, Korth. Verh. Nat. Gesch. p. 157.

Borneo. — Banjarmassin (Motley, n. 1112). Sarawak (Beccari, n. 1500). Saribas (Haviland, n. 1560). Tawaran (Burbidge, n. ?). Pankalan Banggi (Fraser, n. 260). British N. Borneo (Creagh, n. ?), (— ?), (Lowe, n. ?).

Ins. Philippinæ.—Luzon (Vidal, n. 1445).

There are in the Kew Herbarium seven specimens of this species, six from Borneo and one from the Philippines: they exhibit a great deal of variation in the leaves and calyx-lobes, but I cannot separate them into distinct species. They differ from Korthals's description in that the peduncles are pubescent and the stigmas subglobose; they seem to agree with the spceimens in the Leiden Herbarium, none of which, however, are in fruit. Although the calyx-tubes cohere, in every other respect they differ from *Sarcocephalus*; they do not thicken in the free portion as in *Sarcocephalus*, so that the fruit, instead of presenting cupular depressions, presents conical elevations. The manner in which the endocarp in the upper part of the fruit becomes thickened and pithy is quite peculiar; it perhaps aids the fruit to float on the surface of the water. The species generally grows by the side of rivers. In the Philippine specimen the endocarp separates readily, but in the Bornean specimens it is firmly attached to the calyx-tube. In most of the specimens some of the branchlets have hollow swellings which have been inhabited by ants. I suspect that this plant is the *Sarcocephalus macrocephalus* of K. Schumann, of which I have not, however, been able to find any description.

Plate 2.—1. In bud, nat. size. 2. In flower, nat. size. 3. Flower. 4. Calyx. 5. Stigma. 6. Section of ovary. 7. Fruit, nat. size. 8. Fruit, enlarged. 9. Seed.

8. Nauclea nitida, n. sp.

Typus (*Callery*, n. 55) *in Herb. Paris.*

Folia 11 cm. longa, 4 cm. lata, oblonga, apice obtusa, basi attenuata, glabra, nitida, coriacea, nervis 5–6. Petioli 1 cm., complanati. Ramuli tenues, pallidi. Pedunculi 25 mm., ternati, complanati, sub apice bracteati. Capitula sine corollis 5 mm.

Corollæ tubus 5 mm., glaber; lobi breves. Antheræ usque ad summum tubum pervenientes. Stylus 9 mm. Calycis loborum partes deciduæ 1 mm., clavatæ, apice obtusæ, glabræ, non flavæ, partes persistentes sublanceolatæ, pubescentes.

INS. PHILIPPINÆ (Callery, n. 55).

9. NAUCLEA CELEBICA, n. sp.

Typi (*Riedel*, n.?) *in Herb. Kew. etc.*

Folia 21 cm. longa, 8 cm. lata, elliptico-oblonga, apice obtusa, basi acuminata, coriacea, glabra, subglauca, nervis 11. Petioli 12 mm. Ramuli tenues. Pedunculi 2 cm., ternati, complanati, sub apice bracteati. Calycis tubus 1 mm., superne pubescens; lobi 2 mm., pubescentes, subclavati, apice obtusi, non flavi. Ovula numerosa. Receptaculum hirsutum.—*N. lanceolata*, K. Schum. in Engl. et Prantl, Pflanzenf. iv. 4. 59, *not of Blume.*

MALASIA.—Celebes; Gorontalo (Riedel).

The specimens of this plant are in bud only; the branchlets present numerous hollow swellings which have been inhabited by ants.

10. NAUCLEA LANCEOLATA, *Blume.*

Arbor. Folia 11 cm. longa, 4 cm. lata, elliptico-lanceolata, apice longe caudata, basi attenuata, coriacea, glabra, nervis 4–6 obliquis. Petioli 8 mm., pubescentes, glabri, teretes. Stipulæ 9 mm., ovatæ, glabræ. Ramuli tenues, pubescentes vel glabri, internodiis 2–6 cm. Pedunculi 2 cm., sæpissime solitarii, pubescentes, tenues, supra medium bracteati. Corollæ tubus 4 mm., pubescens; lobi 4 vel 5, extra pubescentes. Antheræ oblongæ, obtusæ vel brevissime apiculatæ, usque ad summum tubum pervenientes. Stylus 9 mm. Calycis loborum partes deciduæ 3 mm., spathulatæ, hirsutæ, partes persistentes lanceolatæ, hirsutæ; tubus brevis.—*N. lanceolata*, Blume, Bijdr. p. 1010; Miq. Ann. Mus. Lugd.-Bat. iv. 183. *N. affinis*, Miq. Fl. Ind. Bat. ii. 137. *Cephalanthus orientalis*, Blume, Cat. Gew. Buitenz. p. 38.

JAVA (Blume, hb. Miquel).

This species is allied to the Philippine *N. gracilis* and *N. philippinensis*, and could almost as well be placed in Section 1 of the genus; but I have not found any bracteoles. Vidal, n. 1480, from Luzon, in the Kew Herbarium, belongs to another allied species, but it is too incomplete for description. The descriptions of *N. lanceolata* given by Korthals in Verh. Nat. Gesch., and by Miquel in Fl. Ind. Bat. ii. 138, do not apply to this species; nor, as Miquel has pointed out (Ann. Mus. Lugd.-Bat. iv. 183), is there any trustworthy evidence that *N. lanceolata*, Blume, grows in Sumatra.

11. NAUCLEA TENUIS, n. sp.

Typus (*Forbes*, n. 535) *in Herb. Kew.*

Folia 10 cm. longa, 5 cm. lata, elliptico-obovata, apice caudata, basi attenuata, glabra, nervis 7–8 obliquis. Petioli 7 mm. Stipulæ 7 mm., oblongæ. Ramuli tenues, glabri, internodiis 8–70 mm. Pedunculi 15 mm., tenues, sub apice bracteati. Capitulum fructuum 8 mm. Calycis loborum partes deciduæ 2 mm., spathulatæ, sparse hirsutæ, partes persistentes ovato-lanceolatæ, basi hirsutæ.

NEW GUINEA.—Sogeri Region (Forbes, n. 535).

12. NAUCLEA ANGUSTIFOLIA, n. sp.

Typus (*Haviland*, n. 2150) *in Herb. Kew.*

Folia 16 cm. longa, 2 cm. lata, linearia, utrinque attenuata, coriacea, glabra, nervis 9. Petiolis breves. Ramuli tenues, internodiis brevibus superne dilatis. Pedunculi 2 cm., solitarii, superne incrassati, sub apice bracteati. Bracteæ duæ foliaceæ 32 mm. lineares, basi angustatæ, coriaceæ, glabræ, duæ stipulaceæ 26 mm,, basi latæ, membranaceæ, pubescentes. Corollæ tubus 4 mm., latus, glaber; lobi extra pubescentes. Antheræ ovatæ, usque ad summum tubum pervenientes. Stylus 7 mm. Calycis lobi subpersistentes 4 mm., hirsuti, spathulati, minute apiculati; tubi pars superior 1 mm. Fructus 2 mm.

BORNEO.—Sarawak (Haviland, n. 2150).

PLATE 3.—1. In bud, nat. size. 2. In flower, nat. size. 3. Flower. 4 & 5. Calyx-lobes. 6. Section of corolla. 7. Stigma.

13. NAUCLEA CHALMERSII, *F. Muell.*

Ramuli glabrescentes, foliis confertis, internodiis 5 mm. Folia 1 dm. longa, 22 mm. lata, lineari-lanceolata, utrinque attenuata, subsessilia, coriacea, supra nitida, glabrescentia, nervis 8–9. Stipulæ 14 mm., oblongæ, obtusæ, pubescentes. Pedunculi 3 cm., sub apice bracteati, solitarii. Capitula 25 mm. Corollæ tubus glaber, 7 mm. Antheræ oblongæ usque ad summum tubum pervenientes. Calycis loborum partes deciduæ 6 mm., subulatæ, apice non dilatatæ; partes persistentes sublanceolatæ, sparse hirsutæ, conspicue uni-nerviæ. Fructus 6 mm., coccis 2-partitis. —*N. Chalmersii*, F. von Muell. Notes Papuan Pl. No. 8.

NEW GUINEA.—Sogeri Region (Forbes, nn. 8, 191).

The above description is taken chiefly from F. von Mueller's description, but in part from two specimens in bud in the Kew Herbarium which seem to belong to this species.

14. NAUCLEA CYCLOPHYLLA, *Miq.*

Typi in Herb. Leiden.

Folia 45 cm. longa, 36 cm. lata, late ovata, apice apiculata, basi subcordata, coriacea, glabra, nervis 10–12. Petioli 4 cm., crassi, glabrescentes. Internodia 6 cm., crassa. Pedunculi 1 dm., solitarii, complanati, sub apice bracteati. Bracteæ 35 mm., coriaceæ, apice obtusæ. Capitula sine corollis 4 cm. Calycis lobi villosi, lineares, clavati, apice acuminati. Placentæ pendulæ; ovula deorsum imbricata.—*N. cyclophylla*, Miq. Ann. Mus. Bot. Lugd.-Bat. iv. 181.

MOLUCCAS.—Batjar (de Vriese, Teysmann).

15. NAUCLEA MEDIA, n. sp.

Typus (*Callery*, n. ?) *in Herb. Paris.*

Ramuli ochroleuci, internodiis 25 mm. Folia 22 cm. longa, 10 cm. lata, elliptico-obovata, breviter et obtuse acuminata, coriacea, glabra vel subtus sparse hirsuta, nervis 9–11. Petioli 2 cm. Pedunculi 2 cm.; bracteæ ab apice 6 mm. distantes. Capitula sine corollis 25 mm., sine lobis calycum 12 mm. Corollæ tubi 1 cm. Antheræ usque ad summum tubum pervenientes. Stylus 2 cm.; stigma subglobosum. Calycis loborum partes deciduæ 8 mm., elongato-fusiformes, pubescentes, partes persistentes 4 mm., lineari-lanceolatæ; tubus $1\frac{1}{2}$ mm., subglaber. Receptaculum hirsutum.

INS. PHILIPPINÆ.—Luzon (Vidal, n. 1463).

16. NAUCLEA FORSTERII, *Seem.*

Arbor. Folia 12 cm. longa, 6 cm. lata, orbicularia vel elliptico-obovata, breviter obtuse acuminata, basi interdum attenuata, coriacea, glabra, nervis 8. Petioli 1–2 cm. Stipulæ ovatæ, 12 mm., basi pubescentes. Pedunculi 5 cm., solitarii vel ternati, sub apice bracteati. Bracteæ caducæ. Capitula 3 cm. Corollæ tubus 7 mm., glaber. Antheræ lineares apiculatæ, usque ad basin loborum corollæ pervenientes. Calycis loborum partes deciduæ 5, clavatæ, villosæ, isabellinæ, partes persistentes $1\frac{1}{2}$ mm., villosæ; tubus subglaber. Cocci ab axibus persistentibus caduci. Receptaculum hirsutum.—*N. Forsterii*, Seem. Fl. Vit. p. 121. *N. orientalis*, Forst. f. Prodr. n. 85, p. 15. *N. rotundifolia*, Guill. in Ann. Sc. Nat. vii. (1837) p. 25.

INS. PHILIPPINÆ.—Luzon: Prov. Albany (Cuming, n. 878).

INS. MARIS PACIFICI.—Society Islands (Forster, n. ?), (Beechey, n. ?), (Matthew, n. ?), (Hinds), (Bertero). Tonga Islands (Lister). Samoa (Powell n. ?) (Whitmee). Fiji (Horne).

A large tree with spreading branches; its wood is light-coloured, fine, and durable. The Philippine specimens (Cuming, n. 878) differ somewhat from the Polynesian specimens, but these differ amongst themselves.

17. Nauclea cyrtopoda, *Miq.*

Typus (?).

Ramuli robusti, subpurpurei, internodiis 3–6 cm. Folia 22 cm. longa, 10 cm. lata, elliptico-oblonga, abrupte acuminata, coriacea, glabra, nervis 14. Petioli 17 mm., crassi. Pedunculi solitarii, 4 cm.; bracteæ ab apice 10 mm. distantes. Capitula sine corollis 25 mm. Corollæ tubus 16 mm.; lobi 5, glabri. Antheræ lineares apiculatæ, usque ad summum tubum non pervenientes. Stylus 28 mm. Calycis loborum partes caducæ 4 mm., filiformes, minute clavatæ, apice flavæ, partes persistentes 3 mm., lineari-lanceolatæ, castaneæ, glabræ; tubus 2 mm., hirsutus. Receptaculum hirsutum, setis glabris.—*N. cyrtopoda*, Miq. Fl. Ind. Bat. ii. 342.

Malasia.—Borneo (Lowe), Sarawak (Haviland, n. 198 *b. r. e. t.*, n. 713 *d. k. r. o*). Sumatra: Padang (Junghuhn, Beccari, n. 719). Java.

Miquel's description was taken from a Sumatran specimen. The above description is taken from a Bornean specimen, which is probably a variety of Miquel's plant, but quite possibly it may prove to be a closely allied species. The most distinctive characters of these plants are the anthers not reaching to the top of the tube, the size, shape, and glabrous character of the persistent portions of the calyx-lobes, the solitary peduncles, and the size of the plants; their branches often present hollow swellings which have been inhabited by ants; they are nearly allied to *Nauclea peduncularis*. In the Kew Herbarium are three specimens from Borneo and two from Sumatra. In the Leiden Herbarium are two specimens from Sumatra and one from Java, but none of the Sumatran specimens are in flower: in these the tips of the calyx-lobes seem to be much more elongate than in the Bornean specimens; in two of them the flower-heads seem to be almost sessile, probably because the foliaceous bracts are large and persistent; in one plant at Leiden the stipuliform bracts still enclose the young head, they are 6 cm. long and strongly keeled down the middle. Miquel in Ann. Mus. Bot. Lugd.-Bat. iv. 180 refers his *Nauclea cyrtopoda* to *Anthocephalus indicus*, and says that it is a form with short petioles and swellings on the branchlets. This is impossible.

18. Nauclea peduncularis, *G. Don.*

Typi (*Wallich*, n. 6091).

Ramuli purpurei. Folia 29 cm. longa, 14 cm. lata, elliptico-

oblonga, obtuse acuminata, coriacea, glabra, nervis 10–12. Petioli 2 cm. Pedunculi sub apice bracteati, ternati; medius sæpe brevior, 8 mm., laterales sæpe longiores 2 cm. Capitulum sine corollis 15 mm. Corollæ tubus 1 cm., glaber. Stylus 2 cm. Antheræ lineares, apiculatæ, usque ad summum tubum non pervenientes. Calycis loborum partes deciduæ 6 mm., apicem versus sensim clavatæ, partes persistentes $1\frac{1}{2}$ mm., densissime hirsutæ; tubus $1\frac{1}{2}$ mm. Receptaculum maxime hirsutum.—*N. peduncularis*, Wall. List, n. 6091; G. Don, Syst. iii. 469; Hook. f. Fl. Brit. Ind. iii. 27.

MALAY PENINSULA.—Penang (Wallich, n. 6091; Curtis, n. 1056).

MALASIA.—Borneo: Sarawak (Beccari, n. 1890).

This plant is closely allied to *N. purpurascens*, but is more robust; it seems to be the representative form of it in Penang and North-western Borneo. The length of the corolla-tube differs considerably in the few dried specimens which I have seen.

19. NAUCLEA PURPURASCENS, *Korth.*

Arbuscula. Ramuli purpurei, internodiis 4–8 cm. Folia 18 cm. longa, 8 cm. lata, elliptica vel elliptico-oblonga, coriacea, glabra, nervis 8–10. Petioli 15 mm. Stipulæ 18 mm. longæ, 4 mm. latæ, oblongæ vel subspathulatæ. Pedunculi solitarii vel ternati, 3 cm. Capitula 35 mm. Corollæ tubus 9 mm., glaber. Stylus 18 mm. Antheræ lanceolatæ apiculatæ, usque ad summum tubum non pervenientes. Calycis loborum partes caducæ 6 mm., a basi ad apicem sensim incrassatæ, apice flavæ, partes persistentes 1 mm., dense hirsutæ; tubus 1 mm. Receptaculum hirsutum.—*N. purpurascens*, Korth. Verh. Nat. Gesch. p. 158. *N. Blancoi*, Vidal, Phan. Cum. Phil. p. 175. *N. purpurea*, Blume, Bijdr. p. 1008.

MALASIA.—Borneo: Banjarmassin (Motley, n. 526). Java (Lobb, n. ?), (Kurz, n. ?); Prov. Bantam (Forbes, n. 521). Celebes: Kandari (Beccari, n. ?). Ins. Philippinæ: Luzon; Prov. Albany (Cuming, n. 890).

20. NAUCLEA PALLIDA, *Reinw.*

Typus in Herb. Leiden.

Arbuscula. Ramuli avellanei, foliis sæpe ad apices confertis, internodiis 5–90 mm. Folia 16 cm. longa, 5 cm. lata, elliptico-lanceolata, vel oblongo-lanceolata, obtuse acuminata, supra nitida, subtus glabra vel pubescentia, nervis 8–10. Petioli 5 mm., complanati. Stipulæ 8–12 mm., ovatæ vel oblongatæ, subpersistentes, glabræ vel pubescentes. Pedunculi solitarii, rarius

ternati, pallidi, sub apice bracteati. Bracteæ subpersistentes, 2 cm., lanceolatæ, obtusæ, pubescentes. Capitula 35 mm. Corollæ tubus 8 mm.; lobi 4 vel 5, glabri. Antheræ lineares, apiculatæ, usque ad summum tubum pervenientes. Stylus 15 mm. Calycis loborum partes deciduæ 4 mm., filiformes, abrupte clavatæ, apice flavæ, partes persistentes 1½ mm., sublanceolatæ, sparse hirsutæ. Receptaculum sparse hirsutum.—*N. pallida*, Reinw. ex Blume, Cat. Gew. Buitenz. p. 38. *N. imbricata*, Blume, ex Miq. Ann. Mus. Lugd.-Bat. iv. 18. *N. orientalis*, Blume, Bijdr. p. 1008. *N. purpurascens*, Miq. Ann. Mus. Lugd.-Bat. iv. 182. *N. lanceolata*, var. *longifolia*, Miq. Fl. Ind. Bat. ii. 138.

MALASIA.—Sumatra (Marsden). Java (Zollinger, n. 344; Teysmann, Spanoghe, hb. Miquel).

This species, as well as *N. purpurascens*, seems to be not uncommon near Buitenzorg. Blume does not appear to have confused them together; his difficulty seems to have been in not knowing what Linnæus meant by *N. orientalis*, and in having never seen a specimen of *N. purpurea*, Roxb. Why Miquel should have confused this species first with *N. lanceolata* and then with *N. purpurascens* it is difficult to say; unless he was impressed with a belief that the species of *Nauclea* were fewer than they really are. At first sight the leaves of this species resemble those of *N. purpurascens*, but the petioles are broader, and a little practice leaves no difficulty in distinguishing the specimens even in the absence of flowers and stipules.

21. NAUCLEA NICOBARICA, n. sp.

Typus (Soc. Unitat. Frat.) in Herb. Brit. Mus.

Ramuli pallidi. Folia 14 cm. longa, 8 cm. lata, obovato-elliptica, breviter acuminata, basi asymmetrica, coriacea, glabra, nervis 7–8. Petioli 12 mm., complanati. Stipulæ 18 mm., oblongæ. Pedunculi 4 cm., solitarii vel ternati, sub apice bracteati. Corollæ tubus 9 mm., glaber. Antheræ apiculatæ, summum tubum leviter excedentes. Calycis loborum partes persistentes 1 mm., sublanceolatæ, pubescentes.—*N. purpurascens*, var. *latifolia*, Korth. ex Miq. Ann. Mus. Bot. Lugd.-Bat. iv. 182.

INS. NICOBAR (Kurz, n. 26140). Sumatra?

The type specimen in the British Museum is in flower. In the Kew Herbarium is a specimen in fruit, which is noticed in Hook. f. Fl. Brit. Ind. iii. 24 under *Adina Griffithi*. There are some specimens in the Leiden Herbarium from Sumatra labelled *Nauclea purpurascens*, var. *latifolia*, Korth.; they do not belong to *N. purpurascens*, but probably belong to this species.

22. NAUCLEA SYNKORYNES, *Korth.*

Arbuscula. Ramuli pallidi, internodiis superne subdilatatis. Folia 15 cm. longa, 7 cm. lata, oblongo-lanceolata vel elliptica, coriacea, glabra, nervis 8–9. Petioli 1–2 cm., in plantis exsiccatis nigri. Stipulæ lineares, obtusæ, 6 mm., glabræ. Pedunculi ternati vel solitarii, 6 cm., erecti. Capitula sine corollis 9 mm. Corolla alba, tubo 6 mm. glabro, lobis extra pubescentibus. Antheræ usque ad summum tubum pervenientes. Stylus 13 mm. Calycis loborum partes deciduæ 3 mm., filiformes, breviter clavatæ, apice flavæ, partes persistentes 1½ mm., sublanceolatæ, dense hirsutæ. Cocci 6 mm., seminibus 4 mm. Receptaculum sparse hirsutum.—*N. synkorynes*, Korth. Verh. Nat. Gesch. p. 160.

MALASIA.—Borneo: Sarawak (Beccari, n. 1095), (Haviland, n. 1559). Sumatra (Teysmann). Celebes: Lepo-Lepo (Beccari, n.?). Cambodia (Pierre, n. 552).

23. NAUCLEA EXCELSA, *Blume.*

Ramulorum internodia compressa. Folia 17 cm. longa, 8 cm. lata, elliptico-ovata, obtuse acuminata, basi rotundata, coriacea, glabra, nervis 9–10. Petioli 2 cm., complanati. Stipulæ 1 cm., oblongæ, carinatæ. Pedunculi 5 cm., ternati, complanati, sub apice bracteati. Bracteæ stipulaceæ 1 cm., oblongæ, carinatæ. Capitula sine corollis 6 mm. Corollæ tubus 5 mm., superne pubescens; lobi breves, extra pubescentes. Antheræ apiculatæ, summum tubum leviter excedentes. Calycis loborum partes persistentes lineari-lanceolatæ, pubescentes. Receptaculum hirsutum.—*N. excelsa*, Blume, Bijdr. p. 1009.

JAVA (Blume).

A specimen collected by Kurz in West Java and labelled *Nauclea excelsa*, Blume, does not belong to this species; it is probably a variety of *Nauclea purpurascens*. Some of the axes of the fruit-capsules are persistent and have been mistaken for bracteoles.

24. NAUCLEA MOLLIS, *Blume.*

Folia 13 cm. longa, 7 cm. lata, elliptico-obovata, obtuse obscure acuminata, basi rotundata, supra glabra, subtus pubescentia, nervis 10 subtus prominentibus. Petioli 1 cm., pubescentes. Stipulæ 8 mm., obovatæ, carinatæ, subtomentosæ. Pedunculi 35 mm., laterales, divergentes, sub apice bracteati. Capitula sine corollis 8 mm. Corollæ tubus 6 mm., superne pubescens. Stylus 1 cm. Calycis loborum partes caducæ 2 mm., filiformes, abrupte clavatæ, apice flavæ, partes persistentes sublanceolatæ, hirsutæ.—*N. mollis*, Blume, Bijdr. p. 1010.

JAVA (De Vriese).

This may be but a variety of *N. excelsa*. In the Leiden Herbarium none of the specimens are in flower; in the Kew Herbarium is a flowering specimen with smaller leaves, in which the peduncles are shorter than in *N. excelsa* and the lateral ones are more diverging.

25. NAUCLEA OBTUSA, *Blume*.

Ramuli pallidi. Folia 10 cm. longa, 6 cm. lata, ovata vel obovata, obtuse acuminata, basi vix subcordata, glabra, nervis 7–9. Petioli 18 mm. Stipulæ 15 mm., obovato-oblongæ. Pedunculi 2–5 cm., solitarii vel sæpissime ternati, superne incrassati. Bracteæ fugaces. Antheræ lineares, apiculatæ, usque ad summum tubum pervenientes. Stylus 14 mm. Calycis loborum partes caducæ 3 mm. filiformes, breviter clavatæ, apice flavæ, partes persistentes 2 mm., apice lanceolatæ subulatæ. Receptaculum hirsutum, setis glabris interfloralibus sæpe additis. Cocci 8 mm. fulvi. Axes fructuum persistentes.—*N. obtusa*, Blume, Bijdr. p. 1009; Korth. Verh Nat. Gesch. Bot. p. 158. *N. cordata*, Blume, Bijdr. p. 1011.

Var. (*a*) *minor*. Folia 10 cm. longa, 6 cm. lata, 7-nervia, petiolis 18 mm.

Var. (*b*) *major*. Folia 18 cm. longa, 11 cm. lata, 9-nervia, petiolis 4 cm.

MALASIA.—Java (Blume, Junghuhn, de Vriese, hb. Miquel). Sumatra (Beccari, n. 265).

I have united Blume's two species *N. obtusa* and *N. cordata*; the latter name in any case could not stand, for *N. cordata* of Roxburgh is older. Korthals's description of *N. obtusa* clearly applies to var. (*b*) *major*, but some specimens of var. (*a*) *minor* collected by Blume himself are labelled *N. obtusa*. Miquel in Ann. Mus. Bot. Lugd.-Bat. iv. 181 corrects his previous statements in his Fl. Ind. Bat., and describes the larger form as *N. cordata* and the smaller form as *N. obtusa*. Blume gives no measurements, and his descriptions are too brief.

26. NAUCLEA BARTLINGII, *DC.*

Ramuli glabrescentes. Folia 14 cm. longa, 5 cm. lata, lanceolata, obtusa, basi rotundata vel subcordata, supra glabra, subtus pubescentia, 7–9-nervia, nervulis reticulatis conspicuis. Petioli 6 mm., complanati, pubescentes. Stipulæ 18 mm., oblongæ, hirsutæ. Pedunculi ternati vel solitarii, 3 cm., sub apice bracteolati. Bracteæ caducæ, duæ 5 mm. lineares subspathulatæ, duæ subtriangulares. Capitulum 3 cm. Corollæ tubus 6 mm., lobi extra sparse hirsuti. Antheræ usque ad summum tubum pervenientes. Calycis loborum partes caducæ 4 mm., filiformes,

breviter clavatæ, partes persistentes truncatæ. Cocci 6 mm. Axes persistentes. Receptaculum subglabrum.—*N. Bartlingii*, DC. Prod. iv. 344. *N. mollis*, Bartl. in Herb. Haenke, ex DC. loc. cit. *N. Cumingiana*, Vidal, Phan. Cum. Philip.

INS. PHILIPPINÆ.—Luzon (Vidal, nn. 1460, 1484, 1485); Centre of Luzon (Vidal, n. 365); Prov. Nuena (Vidal, n. 2947); Prov. Batangas (Cuming, n. 1522); Prov. Tayabas (Cuming, n. 833). Ins. Pamar (Vidal, n. 833).

27. NAUCLEA RETICULATA, n. sp.

Typus (*Vidal*, n. 2955) *in Herb. Kew.*

Ramuli robusti, castanei, pubescentes, internodiis 4 cm., superne dilatatis. Folia 24 cm. longa, 19 cm. lata, apice obtusa, basi cordata, coriacea, supra glabra, subtus pubescentia, nervis 8, nervulis reticulatis conspicuis. Petioli 2 cm., crassi, pubescentes. Stipulæ 4 cm., ovatæ, pubescentes, amplexicaulæ. Pedunculi 5 cm., robusti, castanei, complanati, superne pubescentes, sub apice bracteati. Capitulum 4 cm. Corollæ tubus 11 mm., latus, glaber. Antheræ lineares, apiculatæ, usque ad summum tubus pervenientes. Stylus 21 mm. Calycis loborum partes caducæ 6 mm., filiformes, clavatæ, apice flavæ.

INS. PHILIPPINÆ.—Luzon (Vidal, nn. 364, 1473, 2955).

28. NAUCLEA MOLUCCANA, *Miq.*

Typus in Herb. Leiden.

Ramuli obtuse angulati. Folia 15 cm. longa, 8 cm. lata, elliptico-ovata, obtuse acuminata, basi aliquando in petiolum decurrentia, maxime coriacea, glabra, nervis 8 pallidis. Petioli 15 mm. Stipulæ 15 mm., lineares. Pedunculi ternati, complanati, 25 mm., sub apice bracteati. Receptaculum hirsutum, axes fructuum persistentes.—*N. moluccana*, Miq. Ann. Mus. Lugd.-Bat. iv. 183. *N. glabra*, Roxb. Fl. Ind. i. (512).

MALASIA.—Buru.

Although Roxburgh's description of *Nauclea glabra* agrees in every respect with this plant, I have retained Miquel's name because his type specimens exist, whilst there are probably no figures or specimens of Roxburgh's plant. I do not know what *Nauclea glabra*, Blume (Bijdr. 1009) was.

29. NAUCLEA MORINDÆFOLIA, *Blume.*

Typus in Herb. Leiden., Kew., etc.

Ramuli avellanei. Folia 14 cm. longa, 9 cm. lata, ovata, abrupte acuminata, basi rotundata, coriacea, glabra, nervis 8–10 depressis subtus prominentibus. Petioli 2–3 cm., complanati.

Stipulæ 1 cm. longæ, 5 mm. latæ, complanatæ, obovato-oblongæ.—*N. morindæfolia*, Blume, Bijdr. 1011.

MALASIA.—Java; (Blume).

The inflorescence of this plant is not known. Korthals thought the plant was identical with *Anthocephalus indicus*, which it in some respects resembles, but the stipules are not at all the stipules of *Anthocephalus*. Those of *Anthocephalus* are long and folded round the bud, these are quite flat with rounded apex. Minor distinctions are that the bark in this species is avellaneous and corrugated, that the leaves are thicker and more coriaceous, that their nerves are in 8 to 10 pairs, whilst in *Anthocephalus indicus* they are probably never less than 11. The reticulated nerves, though more numerous in this species than is common in *Nauclea*, are less numerous than in *Anthocephalus*.

30. NAUCLEA FAGIFOLIA, *Teysm. et Binn.*

Ramuli teretes, pubescentes tenues. Folia 9 cm. longa, 5 cm. lata, ovata, acuminata, basi rotundata, submembranacea, supra glabra, subtus pubescentia, nervis 10. Petioli 1 cm., tenues, pubescentes. Stipulæ 8–12 mm., complanatæ, pubescentes.—*N. fagifolia*, Teysm. et Binn. Cat. Hort. Bog. p. 117 (nomen tantum).

MALASIA.—Amboina; (hb. Kew, ab Hanbury comm.).

This description is taken from a flowerless specimen in the Kew Herbarium. I have trusted to the label; I do not know of any hitherto published description.

The following species I have not seen:—

NAUCLEA SERICEA, *Spanoghe, in Linnæa*, xv. (1836) 314.

Nauclea vestita, Spanoghe, MS.

Arbor excelsa. Folia longa 18 cm., lata 12 cm., subrotundata, integerrima, supra in venis pubescentia, subtus glauca; ramuli et petioli sericei, pubescentes. Petioli 5 cm. Stipulæ elliptico-oblongæ, concavæ, petiolo breviores, sericeæ. Pedunculi terminales, solitares, petiolo paulo longiores.

In montanis Timor: floret Octobri.

N. sericea, Wall., a synonym of *N. sessilifolia*, is older; so that *N. sericea*, Span., cannot stand as a good specific name.

NAUCLEA GLANDULIFERA, *Spanoghe, in Linnæa*, xv. (1836) 315.

Arbor procera. Folia longa 20 cm., lata 18 cm., obovata, basi subcordata utrinque glabra, parallelo-costata, integerrima, axillis petiolorum glandulosa. Petioli longi 25 mm. Stipulæ ovales obtusæ, glabræ, in dorso basi carinatæ, petiolo longiores. Pedunculi terminales, solitares; fructus subangulati.

Timor: in paludosis et in fruticetis humidis circa Koepang.

I have not seen the plants in Haenke's Herbarium which were named by De Candolle in the 'Prodromus.' These are:—*Nauclea glaberrima, N. Bartlingii, N. canescens, N. rotundifolia,* and *N. calycina.*

The first two are almost certainly *Sarcocephalus glaberrimus* and *Nauclea Bartlingii* as I have described them; the next two are clearly species of *Uncaria,* probably *U. velutina* and *U. insignis.* The last is a species of *Nauclea,* not impossibly *N. purpurascens,* in which case *N. calycina* will be the older name.

There is in the Kew Herbarium a specimen from Miquel's Herbarium labelled *Nauclea oxyphylla,* Miq.; it is identical with another specimen from the same source labelled *Uncaria euryncha,* Miq., but it is not an *Uncaria* or a *Nauclea*; it is not in flower, but it does not belong to this tribe. In Ann. Mus. Lugd.-Bat. iv. 181, Miquel gives *Nauclea oxyphylla* as a synonym for *N. strigosa*; this is probably an error, there is no evidence that *N. strigosa* grows in Sumatra.

I am altogether uncertain about the species in Blanco, Fl. Filip.; they are:—*Nauclea lutea, N. amarilla, N. glandulosa, N. lanceolata, N. latifolia, N. glaberrima, N. glabra, N. calycina, N. obtusa, N. luzoniensis, N. adina, N. digitata.*

Species a genere Naucleâ *exclusæ.*

N. acida, Hunter, in Trans. Linn. Soc. ix. 223 = *Uncaria acida,* Roxb.

N. aculeata, H. B. K. Nov. Gen. et Sp. iii. 382 = *Uncaria tomentosa.*

N. aculeata, Willd. Sp. Pl. i. 929 = *Uncaria guinensis.*

N. adina, Blanco, Fl. Filip. ed. 2. p. 102 = *Mitragyna diversifolia.*

N. adina, Sm. in Rees's Cyclop. xxiv. = *Adina globiflora.*

N. adinoides, Lindl. in Bot. Reg. p. 895 = *Adina globiflora.*

N. africana, Willd. Sp. Pl. i. 929 = *Mitragyna africana.*

N. appendiculata, Walp. Rep. ii. 943 = *Uncaria appendiculata.*

N. aralioides, Miq. Fl. Ind. Bat. iii. 344 = *Adina polycephala.*

N. attenuata, Walp. Rep. ii. 513 = *Uncaria attenuata.*

N. bracteosa, Welw. Syn. Expl. p. 48 = *Mitragyna macrophylla.*

N. Brunonis, Wall. List, n. 6097 = *Mitragyna diversifolia.*

N. Cadamba, Roxb. Hort. Beng. p. 14 = *Anthocephalus indicus.*

N. canescens, Walp. Rep. ii. 513 = *Uncaria canescens.*

N. canescens, DC. Prod. iv. 347 = *Uncaria velutina.*

N. capitellata, Voigt, Hort. Calc. p. 375 = *Adina polycephala.*

N. cinchonæ, DC. Prod. iv. 345 = *Uncaria tomentosa.*

N. citrifolia, Poir. in Lam. Encycl. iv. 345 = *Anthocephalus indicus.*

N. coadunata, Roxb. ex Sm. in Rees's Cyclop. xxiv. n. 6=*Sarcocephalus cordatus.*

N. cordata, Roxb. Hort. Beng. p. 14 = *Sarcocephalus cordatus.*

N. cordifolia, Roxb. Pl. Corom. i. 40 = *Adina cordifolia.*

N. cuspidata, Baker, in Journ. Linn. Soc. xxv. 319 = *Breonia cuspidata.*

N. dasyoneura, Walp. Rep. ii. 513 = *Uncaria dasyoneura.*

N. digitata, Blanco, Fl. Filip. ed. 2. p. 102 = *Heptapleurum Cephalotus.*

N. diversifolia, Wall. List, n. 6096 = *Mitragyna diversifolia.*

N. elliptica, Dalz. et Gibs. Bomb. Fl. p. 118 = *Sarcocephalus missionis.*

N. elliptica, Walp. Rep. ii. 512 = *Uncaria dasyoneura.*

N. ferrea, Blume, Bijdr. 1014 = *Uncaria ferrea.*

N. ferruginea, Blume, Bijdr. p. 1013 = *Uncaria sclerophylla.*

N. Gambir, Hunter, in Trans. Linn. Soc. ix. 218=*Uncaria Gambir.*

N. glaberrima, Bartl. ex DC. Prod. iv. 344 = *Sarcocephalus glaberrimus.*

N. glabrata, Blume, Bijdr. p. 1012 = *Uncaria glabrata.*

N. grandifolia, DC. Prod. iv. 345 = *Sarcocephalus cordatus.*

N. grandifolia, Spreng. Syst. iv. Curæ Post. 81 = *Uncaria macrophylla.*

N. guianensis, Poir. in Lam. Encycl. iv. 436 = *Uncaria guianensis.*

N. Haenkeana, Steud. Nom. ed. 2, ii. 186 = *Uncaria insignis.*

N. Hallii, Walp. Rep. ii. 512 = *Uncaria insignis.*

N. inermis, Baill. in Bull. Soc. Linn. Paris, i. (1879) 201 = *Mitragyna africana.*

N. insignis, D. Dietr. Syn. i. 791 = *Uncaria insignis.*

N. Korthalsii, Steud. Nom. ed. 2, ii. 186 = *Mitragyna speciosa.*

N. lævigata, Walp. Rep. ii. 512 = *Uncaria lævigata.*

N. lanosa, Poir. in Lam. Encycl. Suppl. iv. 61 = *Uncaria lanosa.*

N. latifolia, Sm. in Rees's Cyclop. xxiv. n. 5 = *Sarcocephalus esculentus.*

N. longiflora, Poir. Encycl. Suppl. iv. 63 = *Uncaria* sp. (ex Rumph. Amb.).

N. luzoniensis, Blanco, Fl. Filip. ed. 2. p. 102 = *Mitragyna* sp. (?).

N. luzoniensis, D. Dietr. Syn. Pl. i. 791 = *Uncaria insignis.*

N. macrophylla, Blume, Bijdr. 1010 = *Sarcocephalus cordatus.*

N. macrophylla, Perr. et Lepr. ex DC. Prod. iv. 346 = *Mitragyna macrophylla.*

N. macrophylla, Roxb. Hort. Beng. 14 = *Anthocephalus macrophyllus.*

N. Maingayi, Hook. Fl. Brit. Ind. iii. 27 = *Sarcocephalus Maingayi.*

N. microcephala, Delile, in Caill. Pl. Afr. p. 67 = *Adina microcephala.*

N. microcephala, Wall. ex Voigt Hort. Calc. 375 = *Adina polycephala.*

N. missionis, Hook. f. Fl. Brit. Ind. iii. 27 = *Sarcocephalus missionis.*

N. nemorosa, Walp. Rep. ii. 512 = *Uncaria nemorosa.*

N. oblonga, Miq. ex Hook. f. Fl. Brit. Ind. iii. 27 = *Sarcocephalus missionis.*

N. orientalis, Gaertn. Fruct. i. 151 = *Mitragyna parvifolia.*

N. orientalis, Herb. Madr. ex Wight & Arn. Prod. 392 = *Sarcocephalus missionis.*

N. orientalis, Linn. Sp. Pl. ed. 2. 243 = *Sarcocephalus cordatus* et *S. missionis.*

N. ovalifolia, Spreng. Syst. iv. Curæ Post. 80 = *Uncaria ovalifolia.*

N. parviflora, Pers. Syn. i. 202 = *Mitragyna parvifolia.*

N. parvifolia, Roxb. Pl. Corom. i. 49 = *Mitragyna parvifolia.*

N. parvifolia, Wall. List, n. 6093 *b* = *Sarcocephalus cordatus.*

N. pedicellata, Blume, Bijdr. 1012 = *Uncaria pedicellata.*

N. pilosa, Blume, Bijdr. 1013 = *Uncaria pilosa.*

N. pilulifera, Baill. ex Franch. Pl. Dav. i. 145 = *Adina globiflora.*

N. platanocarpa, Hook. f. Ic. Pl. t. 787 = *Mitragyna africana.*

N. polycephala, A. Rich. in Mém. Soc. Hist. Nat. v. (1834) 289 = *Uncaria tomentosa.*

N. polycephala, Wall. List, n. 6100 = *Adina polycephala.*

N. racemosa, Sieb. et Zucc. in Abh. Akad. Muench. iv. (1846) 178 = *Adina racemosa.*

N. rhynchophylla, Miq. Ann. Mus. Lugd.-Bat. iii. 108 = *Uncaria rhynchophylla.*

N. rotundifolia, Bartl. ex DC. Prod. iv. 346 = *Uncaria insignis.*

N. rotundifolia, Roxb. Hort. Beng. 66 = *Mitragyna diversifolia.*

N. Roxburghiana, Walp. Rep. ii. 513 = *Uncaria Roxburghiana.*

N. Roxburghii, G. Don, Gen. Syst. iii. 469 = *Sarcocephalus cordatus.*

N. sambucina, Winterb. Account Sierra Leone, ii. 45 = *Sarcocephalus esculentus.*

N. scandens, Roxb. ex Hook. f. Fl. Brit. Ind. iii. 30 = *Uncaria sessilifructus.*

N. scandens, Sm. in Rees's Cyclop. xxiv. n. 9 = *Uncaria pilosa.*

N. sclerophylla, Hunter, in Trans. Linn. Soc. ix. 223 = *Uncaria sclerophylla.*

N. sessilifructus, D. Dietr. Syn. Pl. i. 792 = *Uncaria sessilifructus.*

N. sessilis, Spreng. Syst. iv. Curæ Post. 81 = *Uncaria sessilifructus.*

N. setigera, Blume, Bijdr. 1013 = *Uncaria lanosa.*

N. setiloba, Walp. Rep. ii. 943 = *Uncaria setiloba.*

N. silhetiana, D. Dietr. Syn. Pl. i. 791 = *Uncaria macrophylla.*

N. sinensis, Oliver, in Hook. Ic. Pl. t. 1951 = *Uncaria sinensis.*

N. speciosa, Miq. Fl. Ind. Bat. ii. 140 = *Mitragyna speciosa.*

N. speciosa, Walp. Rep. ii. 512 = *Uncaria pedicellata.*

N. sterculiæfolia, A. Rich. in Mém. Soc. Hist. Nat. v. (1834) 289 = *Adina cordifolia.*

N. stipulacea, G. Don, Gen. Syst. iii. 469 = *Mitragyna macrophylla.*

N. stipulacea, Wall. List, n. 6090 *d* = *Sarcocephalus cordatus.*

N. stipulata, Benth. et Hook. Gen. Pl. ii. 31, for *N. stipulosa*, DC.

N. stipulosa, DC. Prod. iv. 346 = *Mitragyna macrophylla.*

N. subdita, Steud. Nom. ed. 2. 186 = *Sarcocephalus subditus.*

N. surinamensis, Miq. in Linnæa, xix. (1847) 129 = *Uncaria tomentosa.*

N. tetrandra, Roxb. Hort. Beng. 14 = *Cephalanthus occidentalis.*

N. tomentosa, Willd. in Roem & Schult. Syst. v. 221 = *Uncaria tomentosa.*

N. trichotoma, Zoll. Syst. Verz. Ind. Arch. 61 = *Adina polycephala.*

N. tubulosa, Arn. ex Thw. Enum. Pl. Zeyl. 137 = *Mitragyna tubulosa.*

N. uncaria, D. Dietr. Syn. Pl. i. 791 = *Uncaria acida.*

N. undulata, Roxb. Hort. Beng. 14 = *Sarcocephalus undulatus.*

N. verticillata, Baill. Adans. xii. (1879) 314 = *Adina microcephala.*

N. Wallichiana, R. Br. in Wall. List, n. 6098 = *Sarcocephalus cordatus.*

N. Wallichiana, Spreng. Syst. iv. Curæ Post. 81 = *Uncaria lanosa.*

N. Wallichii, Wall. List, n. 6098 = *Sarcocephalus cordatus.*

VII. Mitragyna.

(Typi—*M. speciosa, parvifolia, africana.*)

Flores in capitulum globosum compacti, bracteolis paleaceis cincti. Receptaculum hirsutum. Calycis tubus subglaber, parte superiore brevi vel longâ, lobis imbricatis brevibus vel nullis. Corolla infundibularis, fauce subglabrâ vel pilosâ, lobis 5-valvatis. Stamina fauce corollæ inserta; antheræ sæpe lanceolatæ, apiculatæ. Stigma mitratum, basi intrusum. Ovarium biloculare; placentæ pendulæ; ovula numerosa sursum imbricata. Fructus breves, sessiles, apice dehiscentes, endocarpis coriaceis separantibus. Semina complanata, suborbicularia.

Arbores. Folia, nervis transversalibus parallelibus, nervulis reticulatis conspicuis. Stipulæ magnæ, interpetiolares, complanatæ, caducæ. Pedunculi terminales vel axillares, solitarii vel ternati, simplices vel ramosi. Bracteæ prope apices pedunculorum magnæ, duæ sæpe petiolatæ subpersistentes.

Mitragyna, *Korth. Obs. de Naucl. Ind.* p. 19 (1839).
Stephegyne, *Korth. Verh. Nat. Gesch. Bot.* 160 (1840?).
Mitragyne, *Korth. l. c.*
Nauclea, *auct. partim.*
Mamboga, *Blanco, Fl. Filip.* ed. 1. 140 (1837).

Synopsis Specierum.

Sectio 1.—Folia minora. Corollæ lobi extra glabri.
  Pedunculi sæpissime ternati.
    Calycis tubi pars superior brevis cupularis.
      Petioli longiores quam 2 cm. ...... 1. *speciosa.*
      Petioli breviores quam 2 cm.
        Corolla fauce subglabra .... 2. *parvifolia.*
        Corolla fauce pilosa .... 3. *africana.*
    Calycis tubi pars superior tubulosa, elongata...................... 4. *tubulosa.*

Inflorescentia sæpe cymosa. Calycis tubi pars superior subtubulosa.
Calycis limbus breviter lobatus ...... 5. *diversifolia.*
Calycis limbus alte lobatus .... 6. *hirsuta.*

Sectio 2.—Folia majora. Corollæ lobi extra pubescentes.
Calycis lobi breves .... 7. *macrophylla.*
Calycis lobi 1 mm. .... 8. *rubrostipulacea.*

1. Mitragyna speciosa, *Korth.*

Ramuli obtuse angulati. Folia 14 cm. longa, 7 cm. lata, elliptica, abrupte acuminata, basi rotundata vel subcordata, subtus in nervis pubescentia, nervis 15. Petioli 25 mm. Stipulæ 2 cm., lanceolatæ, sparse pubescentes, nervis 9. Pedunculi ternati, 3–5 cm. Bracteæ foliaceæ 4 cm., petiolis 2 cm. Corollæ tubus 5 mm., extra glaber, fauce pilosus; lobi 3 mm., glabri, marginibus revolutis. Stamina reflexa. Stylus 13 mm.; stigma 2 mm. Calycis lobi 5, quatuor breves rotundi, quintus sæpe spathulato-oblongus; tubi pars superior brevis, cupularis. Bracteolæ 4 mm., subglabræ. Receptaculum dense hirsutum. Fructus costæ 10, endocarpiis 4-valvatis.—*M. speciosa*, Korth. Obs. de Naucl. Ind. p. 19 (sine descriptione). *Stephegyne speciosa*, Korth. Verh. Nat. Gesch. Bot. p. 160. *S. parvifolia*, K. Schum. Fl. Kaiser-Wilh.-Land, p. 127. *Nauclea speciosa*, Miq. Fl. Ind. Bat. ii. 140.

Var. (*a*). Folia 15-nervia.—Borneo.

Var. (*b*). Folia 10-nervia.—Ins. Philippinæ; New Guinea.

Malasia.—Borneo: Banjarmassin (Korthals; Motley, n. 1169). Ins. Philippinæ: Luzon (Vidal, n. 798).

New Guinea.—Kaiser Wilhelmsland (Hollrung, n. 674).

2. Mitragyna parvifolia, *Korth.*

Folia maxime varia, sæpe 1 dm. longa, orbicularia, ovata vel elliptica, obtusa vel breviter et obtuse acuminata, basi rotundata, cordata, vel attenuata, supra glabra, subtus pubescentia, nervis 7–8. Petioli 5–20 mm. Stipulæ obovatæ, 15 mm. Pedunculi sæpe ternati, laterales 35 mm. Bracteæ foliaceæ, petiolatæ, persistentes. Corollæ tubus 6 mm., extra glaber, intus subglaber; lobi 2 mm. Stylus 9 mm.; stigma 2 mm. Ovarium 2 mm. Calycis pars superior brevissima, lobi breves rotundati marginibus hirsutis. Bracteolæ 2 mm., superne marginibus hirsutis.

Fructus 5 mm.—*M. parvifolia*, Korth. Obs. de Naucl. Ind. p. 19. *Nauclea parvifolia*, Wight & Arn. Prod. 391; Wight, Ill. t. 123; Bedd. Fl. Sylv. t. 34; Roxb. Pl. Corom. i. 40, t. 52, et Fl. Ind. i. 513; Willd. Sp. Pl. i. 929. *N. parviflora*, Pers. Syn. i. 202; Dalz. & Gibs. Bomb. Fl. 118. *Stephegyne parvifolia*, Korth. in Verh. Gesch. Nat. Bot. 161 partim; Brandis, For. Fl. 262; Hook. f. Fl. Brit. Ind. iii. 25.

INDIA.—Ceylon (Walker, n. 68), (Thwaites, n. 780). Courlattem (Herb. Wight). Kurg (Herb. Wight). Vellyengry Hills (Wight, Kew Distr. n. 1298). Belgaum (Ritchie, n. 341). Madras (Rottler, n. 211; Hooker f. & Thomson). Kanara (Herb. Hohenacker). Central Provinces (Thomson). N.W. India (Royle). N. India (Edgeworth). Gurhwal (Falconer). Kumaon (alt. 1000 ft., Strachey & Winterbottom). Behar (alt. 2000 ft., Hooker f.). Upper Gangetic Plain (Thomson). Rangoon (McClelland). Upper Burmah (Collett, n. 56, n. 855). Mergui (Griffith, Kew Distr. n. 2746).

The Javan plant is not this but *M. diversifolia*. Both this plant and *M. diversifolia* are very variable, and it is this which makes it occasionally difficult to distinguish between them. In this plant the inflorescence is less cymose, the superior portion of the calyx-tube much shorter and more cupular, the top of the bracteoles more hairy, the corolla-tube longer and subglabrous within. The New Guinea specimens which have been referred to this species are *M. speciosa*. The Molucca specimens I have not seen.

3. MITRAGYNA AFRICANA, *Korth.*

Arbor. Ramuli glabrescentes. Folia 7 cm. longa, 4 cm. lata, ovata vel elliptica, obtuse vel obtuse acuminata, basi rotundata vel subcordata, vel attenuata, supra glabra, subtus in nervis hirsuta, nervis 7–8. Petioli 8 mm., pubescentes. Stipulæ 12 mm. Pedunculi 4 cm., axillares et terminales, sub apice bracteati. Bracteæ foliaceæ, 5 cm., petiolis 25 mm., bracteæ stipulaceæ, 14 mm., caducæ. Corollæ tubus 5 mm., extra glaber, fauce pilosus; lobi 2 mm. Stylus 12 mm.; stigma 1 mm. Calycis tubi pars superior brevis cupularis, breviter 5-dentata, pars inferior 1 mm. glabra. Ovula numerosa, complanata. Receptaculum hirsutum. Bracteolæ 3 mm., subglabræ.—*M. africana*, Korth. Obs. de Naucl. Ind. p. 19. *Uncaria inermis*, Willd. in Usteri, Delect. ii. p. 199, t. 3 (1793). *Nauclea africana*, Willd. Sp. Pl. i. 929 (1797). *N. platanocarpa*, Hook. f. in Hook. Ic. t. 787. *Cephalanthus africanus*, Reichenb. MS. in Sieb. Pl.

Seneg. n. 20. *Stephegyne africana*, Walp. Rep. ii. 513; Benth. in Hook. Niger Fl. 380, t. 37.

AFRICA TROP. BOR.—Gambia (Mackenzie, Skuer). Senegal (Roger). Niger (Ansell, Vogel, Barter; Scott Elliot, n. 5378). Baehr el Arab (Schweinfurth, n. 1190).

4. MITRAGYNA TUBULOSA, *Hav.*

Arbuscula. Ramuli obtuse 4-angulati. Folia 13 cm. longa, 7 cm. lata, elliptica, obovata, acuminata, membranacea, subtus in nervis pubescentia, nervis 9–12. Petioli 1 cm. Stipulæ 15 mm., ovatæ, 9–12-nerves. Pedunculi sæpissime ternati, medius sæpe 3 cm., duo laterales 5 cm. Bracteæ foliaceæ 6 cm.; bracteæ stipulaceæ 1 cm. Corollæ tubus 9 mm., extra glaber, intus sparse hirsutus; lobi 3½ mm., glabri. Stylus 15 mm.; stigma 3 mm. Calycis tubi pars superior 4 mm., tubulosa, limbo integro. Fructus decem-costatus, 7 mm.; semina complanata, 4 mm. Receptaculum hirsutum. Bracteolæ 4 mm.—*Stephegyne tubulosa*, Hook. f. in Benth. et Hook. f. Gen. Pl. ii. 32, et Fl. Brit. Ind. iii. 25; Bedd. Fl. Sylv., Anal. Gen. 128, t. xxix. fig. 1. *Nauclea tubulosa*, Arn. in Thw. Enum. Pl. Zeyl. 137; Bedd. Ic. Pl. Ind. Or. t. 18.

INDIA.—Ceylon (Walker in hb. Lindley; Thwaites, n. 1657). Cochin (Johnstone).

5. MITRAGYNA DIVERSIFOLIA, *Hav.*

Arbor. Ramuli pallidi. Folia 14 cm. longa, 10 cm. lata, maxime varia, ovata, apice obtusa vel obtuse acuminata, basi rotundata, rarius subcordata, supra glabra, subtus in nervis pubescentia, nervis 8–9. Petioli 15 mm. Stipulæ 25 mm. Inflorescentia cymosa. Bracteæ foliaceæ 5 cm., petiolis 1 cm.; bracteæ stipulaceæ 2 cm., caducæ. Corollæ tubus 3 mm., extra glaber, fauce pilosus; lobi 2½ mm., glabri. Stylus 9 mm.; stigma 1½ mm. Calycis tubi pars superior 1½ mm., limbo breviter lobato, pars inferior 1½ mm. Bracteolæ 3 mm.—*Stephegyne diversifolia*, Hook. f. Fl. Brit. Ind. iii. 26. *S. parvifolia*, Korth. Verh. Nat. Gesch. p. 161 partim. *Nauclea diversifolia*, Wall. List, n. 6096; G. Don, Gen. Syst. iii. 467. *N. rotundifolia*, Roxb. Fl. Ind. i. 516; Kurz, For. Fl. Burma, ii. 67. *N. Brunonis*, Wall. List, n. 6097; G. Don, loc. cit. *N. parvifolia*, var. 2, Kurz, For. Fl. Burma, ii. 67.

INDIA.—Chittagong (Clarke, n. 16907; Hooker f. & Thomson).

Burma (Brandis, n. 1153). Rangoon (McClelland, Maingay). Pegu (Kurz, n. 1446). Mergui (Griffith, Helfer, Kew Distr. n. 2747).

MALASIA.—Cocos Islands. Ins. Philippinæ—Luzon; Prov. Batargas (Cuming, n. 1523); Centre of Luzon (Vidal, n. 2953); Prov. Nueva Vircaya (Vidal, n. 2958); Manila (Vidal, n. 372). Malpina. Java.

The specimens from Java belong to this species, and not to *M. parvifolia.*

6. MITRAGYNA HIRSUTA, n. sp.

Typus (*Pierre*, n. 1835).

Ramuli fuliginei, pubescentes; internodia 5 cm. Folia 14 cm. longa, 9 cm. lata, ovata, obtusa, basi subcordata, coriacea, supra sparse pubescentia, subtus dense hirsuta, nervis 12–14. Petioli 1 cm., villosi. Stipulæ 12 mm. longæ, 10 mm. latæ. Inflorescentia cymosa, diffusa; pedunculi pubescentes. Bracteæ foliaceæ, maxime variæ; bracteæ stipulaceæ 12 mm., caducæ. Calycis tubi pars superior 1 mm., pars inferior 1 mm.; lobi 2 mm., lineari-oblongi. Bracteæ 3 mm.

COCHIN CHINA.—Bao Chiang (Pierre, n. 1835).

The specimen is in bud only, but the species is readily distinguished not only by the hairiness but also by the calyx-lobes.

7. MITRAGYNA MACROPHYLLA, *Hav.*

Arbor. Ramuli glabri. Folia 18–35 cm. longa, 11–25 cm. lata, maxime variabilia, obovata, obtusa, basi attenuata vel rotundata, in petiolo sæpe decurrentia, coriacea, membranacea, supra glabra, subtus glabrescentia, nervis 7–10. Petioli 2 cm. Inflorescentia sæpe umbellata. Pedunculi ternati, sæpe in multos pedunculos secondarios 5 cm. longos divisi. Bracteæ foliaceæ 4 cm., petiolis 15 mm. Capitulum sine corollis 9 mm. Corollæ tubus 3 mm., glaber; lobi 2 mm., extra pubescentes, apice appendicibus glabris cylindricis deciduis ornati. Calycis tubi pars inferior 2 mm. glabra, pars superior 1 mm.; lobi rotundati, marginibus ciliatis. Bracteolæ 3 mm., sparse hirsutæ. Fructus 5 mm., lateraliter dehiscentes. Semina complanata.—*Stephegyne macrophylla*, Hiern, in Oliver, Fl. Trop. Afr. iii. 41. *Nauclea stipulosa*, DC. Prod. iv. 346. *N. macrophylla*, Perr. et Lepr. ex DC. Prod. *l. c.* *N. bracteosa*, Welw. Synopse Éxplic. p. 48. n. 130. *N. stipulacea*, G. Don, Gen. Syst. iii. 469. *N. stipulata*, Benth. et Hook. f. Gen. Pl. ii. 31.

NORTH TROP. AFRICA.—Fernando Po. Sierra Leone (Scott Elliot, n. 5014). Niger (Barter). Nun River (Mann). W. Tropical Africa,

lat. 10° N. (Mann, n. 1771). Niamniam Land (Schweinfurth). Djurland (Schweinfurth).

SOUTH TROP. AFRICA.—Angola (Welwitsch). Zambesi (Kirk).

PLATE 4.—1. Flower, nat. size. 2. Flower, enlarged. 3 & 4. Bracteoles. 5. Tip of petals. 6. Stigma. 7. Fruit, nat. size. 8. Fruit, enlarged. 9. Section of fruit. 10. Seed.

8. MITRAGYNA RUBROSTIPULACEA, *Hav.*

Typi (*Volkens*, n. 1583).

Arbor. Ramuli pallidi. Folia 30 cm. longa, 24 cm. lata, elliptica, obovata, basi attenuata, glabra, nervis 9 testaceis. Petioli 2 cm. Stipulæ 4 cm., ovatæ. Inflorescentia cymosa. Pedunculi pubescentes 35 mm. Bracteæ foliaceæ 6 cm., stipulaceæ 3 cm., ovatæ, nervis 16. Corollæ lobi valvati, extra pubescentes. Stigma mitratum. Calyx glaber; tubi pars superior 2 mm., lobi 1 mm., imbricati. Placentæ longæ, pendulæ, ovulis sursum imbricatis. Receptaculum hirsutum. Bracteæ numerosæ paleaceæ.—*Adina rubrostipulacea*, K. Schum. in Engler, Pfl. Ost-Africa, C. p. 378.

AFRICA.—Kiboscho, 4400 ft. (Volkens, n. 1583). Ruwenzori (Scott Elliot).

PLATE 4.—11. Bracteole. 12. Calyx.

VIII. UNCARIA.

(Typus *U. guianensis.*)

Flores in capitulum globosum aggregati, sessiles vel pedicellati, ebracteolati, vel bracteolis filiformibus intermixti. Calycis tubi (hirsuti non angulati) pars inferior ovata vel fusiformis, pars superior campanulata, infundibularis vel breviter tubulosa; lobi 5, valvati vel aperti. Corolla tubuloso-infundibularis; fauce glabra; lobi 5, valide imbricati. Stamina 5, fauce corollæ inserta; filamenta brevia; antheræ oblongæ, basi 2-setosæ. Stylus gracilis, longe exsertus; stigma subglobosum, clavatum, vel fusiforme. Ovarium biloculare, placentis linearibus septo affixis, ovulis sursum imbricatis. Capsula sæpe elongata, septicide bivalvis; endocarpum coriaceum, a tubo calycis separans. Semina sursum imbricata; testa utrinque longissime alata, alâ inferiore placento affixâ bipartita; albumen carnosum.

Frutices scandentes. Ramuli 4-angulati, internodiis elongatis. Folia opposita, breviuscule petiolata. Stipulæ interpetiolares, integræ vel bifidæ. Pedunculi solitarii terminales axillaresque, vel

terminales ternati, vel axillares in racemos ternatim verticillatos collecti. Pedunculi axillares, in cirrhos uncinatos steriles sæpe mutati. Bracteæ parvæ, sæpe connatæ.

Uncaria, *Schreb. Gen. Pl.* (ed. 1789) i. 125.
Ourouparia, *Aubl. Pl. Guian. françoise* (1775) i. 177.
Agylophora, *Neck. Elem.* (1790) i. 145.
Restiaria, *Lour. Fl. Coch.* (1790) p. 639.
Uncinaria, *Reichb. Nom.* (1841) p. 230.
Nauclea, *auct. partim.*

Synopsis Specierum.

Sectio 1.

Capsulæ pedicellatæ. Bracteolæ nullæ. Capitulum sæpe terminale, solitarium. Calycis tubi pars superior infundibularis; lobi breves. Foliorum nervuli transversi vix prominentes. Stipulæ bifidæ. Stigma elongatum.

Corollæ tubus 1 cm. .... 1. *africana.*

Sectio 2.

Capsulæ pedicellatæ. Bracteolæ nullæ. Pedunculi axillares. Calycis tubi pars superior infundibularis; lobi triangulares, valvati. Folia valde coriacea, nervulis transversis valde prominentibus. Stigma ovoideum. Stipulæ bifidæ.

Corollæ tubus 25 mm. .... 2. *pedicellata.*
Corollæ tubus 18 mm. .... 3. *insignis.*
Corollæ tubus 14 mm. .... 4. *sclerophylla.*

Sectio 3.

Capsulæ pedicellatæ. Bracteolæ nullæ. Pedunculi petiolis vix bis longiores. Calycis tubi parte superiore lobis breviores. Stipulæ sæpissime integræ.

Stipulæ bilobatæ.
Foliorum nervi transversi obscuri .... 5. *acida.*
Foliorum nervi transversi distincti.... 6. *canescens.*
Stipulæ integræ.
Folia glabra.
Petioli subteretes.
Folia 3-nervia .... 7. *trinervis.*
Folia 4-nervia .... 8. *calophylla.*
Folia 6-nervia.
75 mm. longa .... 9. *jasminiflora.*
100 mm. longa .... 10. *Gambir.*
Petioli alati .... 11. *pteropoda.*

Folia subtus pubescentia.
Calycis lobi ovati.
Folia 3–6-nervia .... 12. *dasyoneura.*
Calycis lobi angusti.
Folia 6-nervia .... 13. *attenuata.*
Folia 8–10-nervia .... 14. *ovata.*
Folia 6–7-nervia, nervis subtus prominentibus .... 15. *borneensis.*

Sectio 4.

Capsulæ pedicellatæ. Bracteolæ nullæ. Pedunculi petiolis multum longiores. Calycis lobi lineares vel filiformes, tubi parte superiore longiores, lobis secundariis sæpe ornati. Stipulæ bilobatæ.

Calycis lobi lineares.
Corollæ tubus hirsutus.
Calycis lobi superne angustiores .. 16. *macrophylla.*
Calycis lobi superne latiores ...... 17. *velutina.*
Corollæ tubus glaber.
Calycis lobi sparse hirsuti .... 18. *lanosa.*
Calycis lobi extra dense hirsuti .... 19. *glabrata.*
Calycis lobi filiformes.
Folia supra glabra .... 20. *setiloba.*
Folia supra hirsuta.
Florum pedicelli cohærentes.
Calycis tubus superne hirsutus .. 21. *Hookeri.*
Calycis tubus superne glaber .... 22. *appendiculata.*
Flores subsessiles................ 23. *ferrea.*

Sectio 5.

Capsulæ sessiles. Bracteolæ filiformes. Inflorescentia pseudo-racemosa vel pseudo-paniculata. Stipulæ sæpissime bilobatæ.

Calycis lobi lineares.
Folia hirsuta.
5-nervia .... 24. *Roxburghiana.*
9-nervia;
lobi calycis superne latiores, 2 mm. 25. *pilosa.*
lobi calycis inferne latiores, 2 mm. 26. *hirsuta.*
lobi calycis 1 mm. .... 27. *tonkinensis.*
Folia glabra.
Stipulæ integræ....... .... 28. *sinensis.*
Stipulæ bifidæ .... 29. *rhynchophylla.*

Calycis lobi brevissimi.

Folia 8-nervia .... 30. *homomalla.*

Folia 5-nervia;

submembranacea .... 31. *lævigata.*

coriacea, subtus glauca............ 32. *sessilifructus.*

Sectio 6.

Capsulæ pedicellatæ. Bracteolæ filiformes. Pedunculi pseudoracemosi. Stipulæ integræ.

Calycis tubi pars superior cupularis .... 33. *tomentosa.*

Calycis tubi pars superior infundibularis . 34. *guianensis.*

1. Uncaria africana, *G. Don.*

Frutex 1–15-metr. Ramuli glabri vel pubescentes; internodi 7–9 cm. Folia 13 cm. longa, 6 cm. lata, elliptico-lanceolata, longe acuminata, supra glabra, subtus glabrescentia, nervis 7–8. Petioli 7 mm. Stipulæ bifidæ, lobis acutis. Pedunculi 7 cm., maxime variabiles. Flores pedicellati vel subsessiles. Corolla sericea, mellea; tubus 1 cm., lobi oblongi. Calyx sericeus; tubi pars superior 4 mm.; lobi 1 mm., obtuse triangulares. Stylus 18 mm.; stigma 4 mm., elongato-clavatum. Capsulæ 2 cm., cum pedicellis æquilongæ. Bracteæ nullæ.—*U. africana*, G. Don, Gen. Syst. iii. 471; Hook. Ic. Pl. t. 781; Benth. in Hook. Niger Fl. 381, t. 42; Hiern, in Oliver Fl. Trop. Afr. iii. 42. *U. madagascariensis,* Baill. in Bull. Soc. Linn. Paris, i. (1879) 219. *Nauclea africana*, Walp. Rep. ii. 512.

Var. (1). Flores subsessiles. Calycis tubi pars superior 4 mm.—Sierra Leone, Niger, Mombuttu.

Var. (2) *madagascariensis.* Flores subsessiles. Calycis tubi pars superior 2 mm.—Mascarenia.

Var. (3) *angolensis.* Flores pedicellati. Calycis tubi pars superior 4 mm.—Angola.

Var. (4). Flores pedicellati. Calycis tubi pars superior 2 mm.—Kamerun.

N. Trop. Africa.—Sierra Leone (Scott Elliot, n. 3832, n. 4709; Johnston, n. 36; Barter, Don). Niger (Vogel, n. 117). W. Tropical Afr., lat. 1° N. (Mann, n. 1769). Mombuttu (Schweinfurth, n. 3486).

S. Trop. Africa.—Angola (Welwitsch, nn. 3030, 3031).

Mascarenia.—Madagascar (Baron, nn. 6218, 5769; Hildebrandt, n. 3449). Ins. Comoro (Humblot, n. 451).

The species is very variable and has a very wide distribution, yet I am unable to group the specimens I have seen into distinct species.

2. UNCARIA PEDICELLATA, *Roxb.*

Ramuli hirsuti. Folia 90–115 mm. lata, longitudinis cum latitudine ratione 15 : 10, ovata vel elliptico-ovata, basi subcordata, maxime coriacea, supra glabra vel hirsuta, subtus hirsuta, nervis 9–10. Petioli 18 mm. Stipulæ 1 cm., bilobatæ; lobi triangulares. Pedunculi steriles 20–25 mm.; pedunculi floriferi 5–14 cm., ferruginei, dense tomentosi. Bracteæ 1 cm. Florum pedicelli 1 cm. Corolla sericea; tubus 25 mm.; lobi 4 mm. Stylus 45 mm.; stigma oblongum, basi abrupte constrictum. Calycis tubi pars inferior 5 mm., pars superior 6 mm., infundibularis; lobi 3 mm., triangulares. Capsulæ 36 mm. Bracteolæ nullæ.—*U. pedicellata*, Roxb. Fl. Ind. i. 520, ed. Carey & Wall. ii. 128; DC. Prod. iv. 349; Korth. Verh. Nat. Gesch. p. 166; Miq. Ann. Mus. Lugd.-Bat. iv. 84. *U. sclerophylla*, Hook. f. Fl. Brit. Ind. iii. 28. *U. speciosa*, Wall. List, n. 6106. *U. ferruginea*, Kurz, For. Fl. Burma, ii. 69. *Restiaria cordata*, Lour. Fl. Cochinch. (ed. 1790), p. 639. *Nauclea pedicellata*, Blume, Bijdr. 1012.

INDIA.—Tenasserim (Griffith). Mergui (Griffith, n. 2764).

MALASIA.—Penang (Maingay, nn. 2256, 2371; Wallich, n. 6106*a*). Malacca (Maingay, n. 2947). Singapore (Anderson, n. 103). Borneo: Sarawak (Beccari, nn. 789, 428; Haviland, n. 836); Labuan (Motley, n. 359). Banca (Miquel). Sumatra. Java (Blume, Lobb, Miquel). Ins. Philippinæ (Vidal, n. 369).

NEW GUINEA.—Sogeri Region (Forbes, n. 104). K. Wilhelmsland (Hollrung, n. 639).

Roxburgh's description of the leaves applies to this plant, and not the smaller species *U. sclerophylla*; he adds that it is a native of the Moluccas, where the smaller form probably does not grow. It is possible that the locality is erroneous, but in the cases of *Nauclea glabra, Nauclea macrophylla,* and *Nauclea undulata,* where the same locality is given, it is correct. Wallich (List, n. 6105) applied both names *U. sclerophylla* and *U. pedicellata* to the smaller form, and he calls this species *U. speciosa.* Blume, DeCandolle, Korthals, and Miquel used *Uncaria pedicellata* for this form, and it is so used in the Leiden Herbarium. Sir Joseph Hooker, however, applied the name *U. sclerophylla* to this species: probably he regarded Wallich's n. 6105 B as the type of *U. pedicellata*; there is nothing on the label of this specimen to show either the date or locality at which it was collected. In referring *Restiaria cordata,* Lour., to this species I have relied upon a specimen so labelled which is in the British Museum.

In whatever way the group to which these plants belong is subdivided into species, unusual forms would still be found which would be difficult

to deal with; but, so far as I can judge from the specimens I have seen, it would be very often possible to guess the part of Malasia from which a particular specimen came; that is to say, that the variations are to a considerable extent correlated with localities. I think it clearer to keep *U. insignis* distinct from *U. pedicellata*, but in keeping it separate I do not wish to assume any real specific limits. The points to be especially noted are the length of the corolla-tube, the length of the calyx-lobes and of the fruit-capsules, the degree of hairiness of the plant, and the size and shape of the leaves.

3. Uncaria insignis, *DC.*

Ramuli fuliginei, subglabri, subacute 4-angulati. Folia 120–135 mm. lata, longitudinis cum latitudine ratione 14 : 10, ovata, coriacea, supra glabra, subtus pubescentia, nervis 10–11. Petioli 1–3 cm. Pedunculi 6–7 cm., ferruginei, pubescentes. Corollæ tubus 18–20 mm. Calycis tubi pars inferior 4 mm., pars superior 6 mm.; lobi 2 mm. Bracteolæ nullæ.—*U. insignis*, DC. Prod. iv. 348. *U. Halli*, Korth. Verh. Nat. Gesch. Bot. p. 165. *U. sclerophylla*, Hook. f. Fl. Brit. Ind. iii. 28. *Nauclea rotundifolia*, DC. Prod. iv. 346. *N. luzoniensis*, D. Dietr. Syn. Pl. i. 791. *N. Haenkeana*, Steud. Nom. ed. 2, ii. 186.

Malasia.—Borneo: Banjarmassin (Motley, n. 859); British North Borneo (Creagh). Ins. Philippinæ: Bohol (Cuming, n. 1811); Luzon (Vidal, nn. 370, 1465).

This species differs from *U. pedicellata* chiefly in being much less pubescent and in the shorter corolla. The typical Philippine form has leaves as large as *U. pedicellata*, but the calyx-lobes are shorter relatively to the calyx-tube. *U. Halli* is a distinct variety with smaller leaves, and with the calyx-lobes half the length of the upper part of the tube, as in *U. pedicellata*. I have not seen a specimen of *Nauclea rotundifolia*, DC., but from the description it seems to be this plant.

4. Uncaria sclerophylla, *Roxb.*

Ramuli pubescentes; internodia 5–8 cm. Folia 6–8 cm. lata, longitudinis cum latitudine ratione 17 : 10, elliptica vel elliptico-ovata, rarius basi cordata, supra glabra, subtus hirsuta, nervis 10–11. Petioli 1 cm. Stipulæ 5 mm. Pedunculi steriles 15 mm., pedunculi floriferi 6–9 cm. Bracteæ 4 mm. Florum pedicelli 1 cm. Corollæ tubus 14 mm., extra sericeus; lobi 3 mm. Stylus 34 mm. Calycis tubi pars inferior $3\frac{1}{2}$ mm., pars superior 5 mm.; lobi $1\frac{1}{2}$ mm. Pedicelli et partes inferiores calycum sæpissime

castanei; partes superiores calycum sæpissime fulvæ. Capsulæ sæpe 14 mm. Bracteolæ nullæ.—*U. sclerophylla*, Roxb. Fl. Ind. i. 520; Miq. Ann. Mus. Lugd.-Bat. iv. 184; Wall. List, n. 6105 A. *U. ferruginea*, DC. Prod. iv. 348; Korth. Verh. Nat. Gesch. 164. *U. pedicellata*, Hook. f. Fl. Brit. Ind. iii. 28; Wall. List, n. 6105 B. *Nauclea sclerophylla*, Hunter, in Trans. Linn. Soc. ix. 223. *N. ferruginea*, Blume, Bijdr. 1013.

MALASIA.—Penang (Phillips; Curtis, n. 1117; Wallich, 6105 A). Malacca (Griffith; Maingay, nn. 1289, 1290). Johore (Cantley). Borneo (Korthals). Banjarmassin (Motley, n. 933). Banca (Kurz). Sumatra (Korthals). Java (De Vriese; Zollinger, n. 512).

Both this plant and *U. pedicellata* grow at Penang, and it seems impossible to be certain which of them Dr. Hunter had before him when he described his *Nauclea schlerophylla*, but his description agrees better with this plant than with the other.

5. UNCARIA ACIDA, *Roxb.*

Ramulorum nodi pubescentes, internodia 3–6 cm. subglabri. Folia 8 cm. longa, 6 cm. lata, ovata, obtuse acuminata, subcoriacea, glabra, in plantis exsiccatis umbrina, nervis 4, nervulis inconspicuis. Petioli 15 mm., graciles, sparse pubescentes. Stipulæ bilobatæ, marginibus pubescentibus. Pedunculi steriles arcte curvi; pedunculi floriferi 3 cm., superne graciles pubescentes. Bracteæ orbiculares, concavæ. Corollæ tubus 7 mm., pubescens. Stigma 2 mm., elongato-clavatum. Calycis tubus 3 mm.; lobi $\frac{3}{4}$ mm., suborbiculares. Capsulæ pubescentes, pedicellatæ. Bracteolæ nullæ.—*U. acida*, Roxb. Fl. Ind. i. 520. *U. ovalifolia*, Roxb. Fl. Ind. i. 519; Hook. f. Fl. Brit. Ind. iii. 30. *Nauclea acida*, Hunter, in Trans. Linn. Soc. ix. 223. *N. ovalifolia*, Spreng. Syst. iv. Curæ Post. 80.

INDIA.—Mergui (Griffith).

MALASIA.—Malacca (Griffith; Cuming, n. 2292). Borneo (Korthals, Lowe); Sarawak (Haviland, n. 913, n. 916); British N. Borneo (Creagh); Banjarmassin (Motley).

Sumatra. Java.

Specimens of this species from various localities frequently have monstrous flowers. This species is called *Uncaria acida* in the Leiden Herbarium, and *U. ovalifolia* in the Kew Herbarium. There can be little doubt that both names are equally accurate, on the whole perhaps *U. acida* is preferable. There is no specimen of this plant in the Kew Herbarium from Sumatra or Java.

6. Uncaria canescens, *Korth.*

Ramuli 6 cm., avellanei, pubescentes. Folia 14 cm. longa, 75 mm. lata, elliptica, acuminata, coriacea, glabra, subtus glauca, pubescentia, nervis 6–8, nervulis transversis conspicuis. Petioli 1–2 cm., pubescentes. Pedunculi steriles 12 mm. Pedunculi floriferi 18–30 mm., pubescentes, superne ferruginei. Bracteæ 3 mm., lanceolatæ. Corollæ tubus 9 mm., hirsutus. Stigma 2 mm., elongatum, clavatum. Calycis tubus 3 mm., dense hirsutus, ochraceus, brevissime pedicellatus, superne intus hirsutus; lobi 1 mm., ovati, intus glabri, nigri. Capsulæ pedicellatæ. Bracteolæ nullæ.—*U. canescens*, Korth. Verh. Nat. Gesch. 172; Hook. f. Fl. Brit. Ind. iii. 29.

Malasia.—Penang (Curtis, n. 331). Malacca (Griffith). Borneo: Labuan (Lobb). Sumatra (Korthals).

None of the specimens I have seen have stipules, but they are probably bifid because the stipulaceous bracts are bifid.

7. Uncaria trinervis, n. sp.

Typus (*Curtis*, n. 1247) *in Herb. Kew.*

Ramuli glabri. Folia 10 cm. longa, 6 cm. lata, obovata, obtuse acuminata, in petiolos aliquanto decurrentia, coriacea, glabra, nervis 3, nervulis transversis numerosis. Petioli 25 mm., graciles. Stipulæ integræ. Inflorescentia racemosa. Pedunculi 2 cm., inferne compressi glabri, superne ferruginei pubescentes. Bracteæ 4 mm., integræ. Capitulum sine corollis 1 cm. Corollæ tubus 5 mm., hirsutus. Stigma 1 mm. Calycis tubus 3 mm., subsessilis, dense hirsutus; pars superior parte inferiore brevior, intus glabra castanea; lobi breves, obtusi. Receptaculum hirsutum. Bracteolæ nullæ.

Penang (Curtis, n. 1247).

8. Uncaria calophylla, *Korth.*

Ramuli glabri. Folia 10 cm. longa, 7 cm. lata, ovata, obtuse acuminata, in petiolos aliquando decurrentia, coriacea, glabra, nervis 4, nervulis transversis numerosis. Petioli 18 mm., graciles. Stipulæ 5 mm., oblongæ, pubescentes. Calycis lobi 1 mm., oblongi. Capsulæ 12 mm., hirsutæ, pedicellatæ.—*Uncaria calophylla*, Korth. Verh. Nat. Gesch. 170.

Borneo (Korthals).

9. Uncaria jasminiflora, *Hook. f.*

Ramuli subglabri, castanei; internodia 4 cm. Folia 75 mm. longa, 45 mm. lata, ovata, obtuse acuminata, coriacea, glabra, in

petiolos aliquando decurrentia, nervis 7 gracilibus, rubris, nervulis transversis numerosis. Petioli 15 mm., graciles. Stipulæ 5 mm., integræ. Pedunculi steriles 1 cm.; pedunculi floriferi 3 cm. Capitulum sine corollis 12 mm. Corollæ tubus 9 mm., extra pubescens. Flores breviter pedicellati. Calycis lobi cum tubo æquilongi. Capsulæ 15 mm. Bracteolæ nullæ.—*U. jasminiflora*, Hook. f. Fl. Brit. Ind. iii. 32; Wall. List, n. 6103 c, f.

Malasia.—Malacca (Griffith; Maingay, nn. 1276, 1428). Singapore (Anderson, nn. 87, 108). Borneo: Sarawak (Haviland, n. 2825)

There is in the Kew Herbarium a specimen (Haviland, *p. b. n. d.*, from Borneo) which probably belongs to this species; it is in fruit only, and the leaves are elliptic and not ovate.

10. Uncaria Gambir, *Roxb.*

Internodia 6 cm. Folia 1 dm. longa, 55 mm. lata, ovata, obtuse acuminata, coriacea, glabra, nervis 6, nervulis transversis parallelis. Petioli 8 mm. Stipulæ 6 mm., obtuse lanceolatæ, integræ. Pedunculi floriferi 3 cm. Bracteæ 5 mm., obtusæ, breviter pubescentes, basi subconnatæ. Capitula sine corollis 15 mm. Corollæ tubus 1 cm., sparse pubescens; lobi extra pubescentes. Stigma 3 mm., oblongum. Calyx breviter pedicellatus, pubescens, lobis obtuse subtriangularibus. Capsulæ 18 mm., pedicellatæ. Bracteolæ nullæ.—*U. Gambir*, Roxb. Hort. Beng. 86, et Fl. Ind. i. 517; Korth. Verh. Nat. Gesch. t. 34; Hayne, Arzn. Gew. x. t. 3; Hook. f. Fl. Brit. Ind. iii. 31. *Nauclea Gambir*, Hunter, in Trans. Linn. Soc. ix. 218, t. 22; Fleming in Asiat. Research. xi. 187.

Malasia.—Malacca (Maingay, n. 1474). Singapore (Lobb, n. 58; Cuming, n. 2403; T. Anderson, n. 95; Burbidge). British North Borneo (Creagh). Sumatra (Cuming, n. 2403). Java (Zollinger, n. 133). —Often cultivated.

11. Uncaria pteropoda, *Miq.*

Internodia 7–10 cm. Folia 18 cm. longa, 12 cm. lata, ovata, breviter et obtuse acuminata, basi attenuata, glabra, coriacea, nervis 7–8, nervulis transversis numerosis. Petioli 15 mm., alati. Stipulæ 1 cm., oblongæ, apice rotundatæ, coriaceæ, glabræ. Pedunculi 25 mm., inferne glabri, superne pubescentes. Bracteæ 6 mm., glabræ, duæ suborbiculares, duæ lineares. Capitula sine corollis 15 mm. Corollæ tubus 1 cm., extra hirsutus; lobi extra dense villosi, intus glabri. Stigma subcylindricum, $2\frac{1}{2}$ mm. Calycis tubi pars inferior 2 mm., sessilis, angulata, hirsuta, pars

superior 2 mm., latior, pubescens; lobi subtriangulares, breves, crassi, obtusi. Receptaculum hirsutum. Capsulæ pedicellatæ, 2 cm., pubescentes. Bracteolæ nullæ.—*U. pteropoda*, Miq. Fl. Ind. Bat. ii. 343; Hook. f. Fl. Brit. Ind. iii. 29.

MALASIA.—Penang (Phillips; Curtis, n. 332). Malacca (Maingay). Borneo (Barber, n. 362); Banjarmassin (Motley, n. 1184). Sumatra (Diepenhorst); Padang (Beccari, n. 670).

NEW GUINEA.—Sogeri Region (Forbes, n. 416).

There is in the Kew Herbarium a specimen (Forbes 416) from New Guinea which may be a variety of this species. The leaves are 120 mm. long and 85 mm. broad, the petiole 15 mm., not winged in the lower part. Peduncles 15 mm. Corolla-tube only 6 mm. Stigma only 1 mm.

12. UNCARIA DASYONEURA, *Korth.*

Ramuli glabri; internodia 4 cm. Folia 11 cm. longa, 5 cm. lata, ovata vel elliptico-ovata, obtuse acuminata, basi in petiolos aliquando decurrentia, nervis 4–6 subtus hirsutis. Petioli 2 cm. Stipulæ 1 cm., integræ, glabræ. Pedunculi steriles 15 mm.; pedunculi floriferi 2 cm. Bracteæ 4 mm., lineares vel oblongæ. Capitula sine corollis 9 mm. Corollæ tubus 7 mm., extra pubescens. Stigma 2 mm. Flores subsessiles. Calycis tubus 3 mm., ferrugineus, hirsutus; pars inferior ovoidea, pars superior subcupularis; lobi ovoidei, intus glabri castanei. Capsulæ angustæ.—*U. dasyoneura*, Korth. Ver. Nat. Gesch. 169; Hook. f. Fl. Brit. Ind. iii. 31. *U. Gambir*, Thwaites, Enum. Pl. Zeyl. 138. *U. elliptica*, R. Br. in Wall. List, n. 6104 A, B partim. *U. acida*, Kew Distrib. no. 827/2 (ex Fl. Brit. Ind. iii. 31). *U. brevispina*, no. 2756 loc. cit.

Var. (1). Folia ovata, 4–5-nervia, basi subdecurrentia; petioli 2 cm., pedunculis æquilongi. Calycis tubi pars superior sparse hirsuta.—Malay Peninsula, Sumatra.

Var. (2). Folia subelliptica, 5–6-nervia, basi subdecurrentia; petioli 2 cm., pedunculis æquilongi. Calycis tubi pars superior sparse hirsuta.—Malay Peninsula.

Var. (3) *Thwaitesii.* Folia subelliptica, 6-nervia. Petioli 15 mm. Pedunculi 30 mm. Corollæ tubus 8 mm. Calycis tubus extra dense ferrugineo-tomentosus.—Ceylon.

INDIA.—Ceylon (Walker, n. 73; Mackenzie; Gardner, n. 1212; Thwaites, n. 1661).

MALASIA.—Penang (Curtis, n. 1070; Phillips); Malacca (Griffith, Maingay). Singapore (Lobb). Sumatra (Korthals).

13. Uncaria attenuata, *Korth.*

Ramuli ferruginei, pubescentes. Folia 12 cm. longa, 7 cm. lata, elliptica, obtuse acuminata, coriacea, supra glabra, subtus subglauca vel ferruginea, pubescentia vel hirsuta, maxime variabilia, nervis 6, nervulis transversis prominentibus. Petioli 1 cm., complanati, hirsuti. Stipulæ 12 cm. longæ, 8 cm. latæ, ovato-oblongæ. Pedunculi 25 mm., dense pubescentes. Bracteæ 4 mm., basi connatæ, hirsutæ. Corollæ tubus 1 cm., extus hirsutus. Stigma 3 mm. Calycis tubus 4 mm., ferrugineus, dense hirsutus; pars superior parte inferiore longior; lobi breves. Flores subpedicellati. Capsula 2 cm., longe pedicellata. Bracteolæ nullæ.—*U. attenuata*, Korth. Verh. Nat. Gesch. Bot. 170; Hook. f. Fl. Brit. Ind. iii. 29. *U. sclerophylla*, Deless. Ic. Select. iii. t. 81.

Malasia.—Penang (Phillips). Borneo (Teysmann, n. 11289). British N. Borneo (Creagh). Sumatra (Korthals). Padang (Beccari, n. 521). Java (? ex Herb. Horsfield).

In the Kew Herbarium is a sheet with label "Herb. Horsfield: *Uncaria ferrea*, Java." On it is mounted a bit of *U. ferrea*, a bit of *U. glabrata*, and a bit of a variety of *U. attenuata*, less robust than usual, leaves less coriaceous, the branchlet and surface of the leaf beneath being only slightly canescent. It is very probable that this piece of *U. attenuata* is really Javan.

14. Uncaria ovata, *Hook. f.*

Typus in Herb. Wall.

Ramuli avellanei, glabri; internodia 6 cm. Folia 13 cm. longa, 55 mm. lata, oblonga, obtuse acuminata, basi subcordata, coriacea, subtus breviter, pubescentia, nervis 8–10, nervulis transversis conspicuis non prominentibus. Petioli 1 cm. Pedunculi 5 cm. Corollæ tubus 9 mm., pubescens; lobi villosi. Calycis tubi pubescentis, pars superior 2 mm.; lobi 1 mm., obtuse triangulares. Receptaculum hirsutum. Bracteolæ nullæ.—*Uncaria ovata*, Hook. f. Fl. Brit. Ind. iii. 29; R. Br. in Wall. List, nn. 6103, 6107, 6112, in parte.

Malasia.—Malpina (Wallich). Borneo: Sungei Landak (Teysmann, n. 11288). British N. Borneo (Creagh).

The specimens from the Malay Peninsula that I have seen generally have 8 pairs of nerves to the leaves. The Bornean specimen was collected by Governor Creagh; it is in young fruit, the leaves have 10 pairs of nerves.

15. UNCARIA BORNEENSIS, n. sp.

Typus (*Creagh* n. ?) *in Herb. Kew.*

Ramuli ferrugineo-tomentosi; internodia 8 cm. Folia 13 cm. longa, 8 cm. lata, ovata, acuta, coriacea, nervis 7–8, nervulis transversis prominentibus. Petioli 12 mm. Nervi, nervuli et petiolæ ferrugineo-tomentosi. Pedunculi 4 cm., ferrugineo-tomentosi. Capsulæ pedicellatæ, ferrugineo-tomentosæ. Calycis tubi pars superior 3 mm., tubulosa; lobi 1 mm., lineares, erecti.

BORNEO.—Sandakan (Creagh).

The specimens from which this description is taken are in young fruit. They were collected by Governor Creagh; the mid-rib of the leaves is thick quite to the apex of the leaf, and is even excurrent. Two raised lines pass down on either side of each internode from the bases of the leaves. In the marked prominence of the veins below the leaf, and the dense ferruginous tomentum, the species seems to approach *U. sclerophylla*; but I expect that, when specimens with stipules and flowers are obtained, it will be found to be allied to *U. attenuata*.

16. UNCARIA MACROPHYLLA, *Wall.*

Internodia 95 mm., sparse hirsuti. Folia 16 cm. longa, 8 cm. lata, elliptica, abrupte obtuse acuminata, coriacea, supra glabra, subtus hirsuta, nervis 8, nervulis transversis prominentibus. Petioli 8 mm. Stipulæ 8 mm., bifidæ, lobis lanceolatis. Pedunculi steriles 15 mm.; pedunculi floriferi 5 cm., graciles. Capitula sine corollis 18 mm. Corollæ tubus 15 mm., hirsutus; lobi extra pubescentes. Stigma $1\frac{1}{4}$ mm. Calycis tubus 3 mm., ochraceus, pubescens; lobi 3 mm., lineares, lobis secundariis. Capsulæ 15 mm. Receptaculum breviter hirsutum. Bracteolæ nullæ.—*U. macrophylla*, Wall. in Roxb. Fl. Ind. (ed. Carey et Wall.) ii. 132; Hook. f. Fl. Brit. Ind. iii. 32. *U. sessilifolia*, Roxb. MS. *ex* Hook. f., *l. c.*

N.E. INDIA.—Bhotan (Griffith, n. 2123). Assam (Griffith). Khasia: Churra (Hooker f. et T. Thomson). Silhet (Wallich, n. 6107; Clarke, n. 18435). Cachar (Keenan). Manipur (Clarke, n. 42580).

17. UNCARIA VELUTINA, *Hav.*

Typi (*Cuming*, n. 503).

Internodia 45 mm., umbrina, puberula. Folia 11 cm. longa, 5 cm. lata, elliptico-oblonga, obtuse acuminata, supra glabra, subtus sparse canescentia, nervis 8, nervulis transversis non prominentibus. Petioli 8 mm., pubescentes. Stipulæ 8 mm., bifidæ, lobis oblongis. Pedunculi steriles 2 cm.; pedunculi floriferi 4 cm., graciles. Bracteæ subovatæ, basi connatæ.

Corollæ tubus 7 mm., pubescens. Calycis tubus pallide hirsutus; lobi 2 mm., lineares, superne latiores. Capsulæ 9 mm., pedicellis 18 mm. Bracteolæ nullæ.—*Nauclea canescens*, DC. Prod. iv. 346.

INS. PHILIPPINÆ.—Luzon (Cuming, nn. 1470, 1503; Vidal, n. 2952).

I have not seen the type specimen of *Nauclea canescens*, DC., but from the description it appears to be this species.

18. UNCARIA LANOSA, *Wall.*

Ramuli subteretes, sparse hirsuti, castanei. Folia 9 cm. longa, 45 mm. lata, elliptico-lanceolata, acuminata, supra subglabra, subtus sparse ferrugineo-hirsuta, nervis 7. Petioli 3 mm. Stipulæ 5 mm., bipartitæ. Pedunculi steriles 1 cm.; pedunculi floriferi 2 cm., sparse hirsuti. Flores pedicellati. Corollæ tubus 1 cm., lobi subglabri. Calycis tubi subglabri, pars superior brevissima; lobi 2 mm., lineares, obtusi, extra sparse hirsuti. Capsulæ longe pedicellatæ. Bracteolæ nullæ.—*U. lanosa*, Wall. in Roxb. Fl. Ind. (ed. Carey et Wall.) ii. 131; Hook. f. Fl. Brit. Ind. iii. 33. *Nauclea lanosa*, Poir. Encycl. Suppl. iv. 64. *N. setigera*, Blume, Bijdr. 1013.

PENANG (Wallich, n. 6110; Curtis, n. 917; Phillips).

19. UNCARIA GLABRATA, *DC.*

Folia 8 cm. longa, 35 mm. lata, ovata, longe acuminata, subglabra, nervis 6 subtus sparsissime hirsutis ferrugineis. Petioli 5 mm. Stipulæ 7 mm., bilobatæ, lobi ovati. Pedunculi 3 cm., glabri. Bracteæ 6 mm., latæ, lobatæ. Flores subsessiles. Capitulum sine corollis 12 mm. Corollæ tubus 13 mm., glaber; lobi extra leviter pubescentes. Stigma 1 mm., subovoideum. Calyx densissime hirsutus; lobis 2 mm. linearibus, obtusis. intus subglabris, lobis secundariis parvis. Capsulæ pedicellatæ, sparse hirsutæ. Bracteolæ nullæ.—*U. glabrata*, DC. Prod. iv. 348. *U. Lobbii*, Hook. f. Fl. Brit. Ind. iii. 33.

MALASIA.—Singapore (Lobb). Borneo: Sarawak (Beccari, nn. 29, 545; Hullett, n. 291; Haviland, n. 960); Sandakan (Creagh). Sumatra (Korthals). Java (Zollinger, O. Kuntze).

Plants occur in the Philippine Islands which could not be distinguished from *U. glabrata*, but they seem to graduate into *U. setiloba*.

20. UNCARIA SETILOBA, *Benth.*

Typus (*Barclay* n.?) *in Herb. Kew.*

Ramuli sparse hirsuti. Folia 9 cm. longa, 45 mm. lata, ellip-

tico-lanceolata, acuminata, subglabra, nervis 7 subtus sparsissime ferrugineo-hirsuta. Petioli 5 mm. Stipulæ 6 mm., bilobatæ. Pedunculi steriles 1 cm.; pedunculi floriferi 3 cm., sparse hirsuti. Bracteæ 6 mm. Capitula sine corollis 16 mm. Corollæ tubus 12 mm., glaber; lobi extra pubescentes. Flores breviter pedicellati. Calyx dense hirsutus; lobi 2½ mm., lineares, apice filiformes, lobis secundariis parvis. Bracteolæ nullæ.—*U. setiloba*, Benth. in Hook. London Journ. Bot. ii. (1843) 223. *U. florida*, Vidal, Phan. Cum. Phil. 176.

Malasia.—Amboina (Barclay). Ins. Philippinæ: Luzon (Cuming, nn. 862 898, 1504; Vidal, nn. 799, 2949).

21. Uncaria Hookeri, *Vidal.*

Typus in Herb. Kew.

Ramuli hirsuti; internodia 7 cm. Folia 10 cm. longa, 5 cm. lata, elliptico-lanceolata, obtuse acuminata, basi sæpe subcordata, submembranacea, hirsuta, nervis 7. Petioli 6 mm. Stipularum lobi acuti. Pedunculi steriles uncinati; pedunculi floriferi 6 cm., hirsuti, pilis albis et ferrugineis intermixtis. Bracteæ 5, laciniis lineari-lanceolatis. Corollæ tubus 13 mm. Flores pedicellati; pedicelli sæpe in fasciculos coaliti. Capitula sine corollis 18 mm. Calyx dense hirsutus, lobis filiformibus, 3 mm., lobis secundariis 1 mm. Capsulæ hirsutæ. Receptaculum proventu fissum. Bracteolæ nullæ.—*U. Hookeri*, Vidal, Pl. Vasc. Filip. p. 149. *U. ferrea*, F. Villar, in Blanco, Fl. Philipp. ed. 3, Nov. App. 105. *Sabicea Perrottetii*, A. Rich. in Mém. Soc. Hist. Nat. v. 228. *Ourouparia Perrottetii*, Baill. in Bull. Soc. Linn. Paris, i. (1879) 227.

Malasia.—Borneo: Saribas (Haviland, n. 1561). Ins. Philippinæ: Luzon (Cuming, nn. 619, 1128; Vidal, nn. 1469, 2967).

This species passes into *U. ferrea*, and probably also into *U. appendiculata*, which it even more closely resembles. The bracts and stipules are narrower than in *U. ferrea*, the leaves are larger and more membranous, the hairs are longer, fewer and paler; but the most characteristic difference is the way in which the pedicels cohere in bundles and the receptacle splits up in fruit. This splitting up of the receptacle is also well seen in some species with sessile fruits. Both this species and *U. appendiculata* have very marked tufts of pale hairs on the under surface of the leaves.

Plate 4.—13. Inflorescence, nat. size. 14. Calyx and section of ovary, enlarged. 15. Stigma. 16. Fruit, nat. size. 17. Fruit, enlarged. 18. Seed.

22. UNCARIA APPENDICULATA, *Benth.*

Typus (*Hinds* n. ?) *in Herb. Kew.*

Ramuli graciles, sparsim ferrugineo-hirsuti. Folia 12 cm. longa, 9 cm. lata, elliptica vel ovata, longe acuminata, submembranacea, sparse ferrugineo-hirsuta, nervis 7–8. Petioli 5 mm. Stipulæ 8 mm. longæ, 5 mm. latæ, bilobatæ, sparse hirsutæ, lobis lanceolatis. Pedunculi steriles, graciles, 12 mm., uncinati; pedunculi floriferi 25 mm., ferrugineo-hirsuti. Bracteæ 8 mm. Corollæ tubi 13 mm., glabri. Stigma 1½ mm., clavatum. Capitula sine corollis 18 mm. Flores pedicellati. Calycis tubi pars inferior longe hirsuta, pars superior subglabra; lobi 4 mm., inferne lanceolati, superne filiformes, longi hirsuti. Pedicelli sæpe in fasciculos coaliti. Bracteolæ nullæ.—*U. appendiculata*, Benth. in Hook. Lond. Journ. Bot. ii. 222. *Ourouparia ferrea*, K. Schum. in Fl. K. Wilhelms-land, p. 128.

NEW GUINEA (Hinds; Hellwig, n. 484; Hollrung, n. 629). Solomon Isles (Wharton).

AUSTRALIA.—Queensland: Mulgrave River (Bailey).

23. UNCARIA FERREA, *DC.*

Ramuli subteretes, ferrugineo-hirsuti. Folia 10 cm. longa, 5 cm. lata, ovata, acuminata, basi subcordata, supra sparse hirsuta, subtus ferrugineo-hirsuta, nervis 8. Petioli 4 mm. Stipulæ 1 cm. longæ, 1 cm. latæ, bipartitæ. Pedunculi steriles 14 mm.; pedunculi floriferi 3 cm., dense ferrugineo-tomentosi. Bracteæ 1 cm., bilobatæ. Flores breviter pedicellati. Capitula sine corollis 2 cm. Corollæ tubus 13 mm.; lobi extra puberuli. Calyx dense hirsutus; lobi filiformes, 3 mm., lobi secundarii 1 mm. Capsulæ sparse hirsutæ. Bracteolæ nullæ.—*U. ferrea*, DC. Prod. iv. 348; Hook. f. Fl. Brit. Ind. iii. 33. *U. Horsfieldiana*, Miq. Fl. Ind. Bat. ii. 151. *Nauclea ferrea*, Blume, Bijdr. 1014.

INDIA.—Tenasserim (Helfer). Mergui (Griffith, n. 849).

MALASIA.—Perak (Curtis, n. 1305). Malacca (Maingay, n. 1450). Borneo: Sarawak (Haviland); Kiau (Burbidge); Tanjong Batu (Creagh). Sumatra (Marsden). Java (Lobb; Zollinger, nn. 751, 3718; Herb. Horsfield).

24. UNCARIA ROXBURGHIANA, *Korth.*

Ramuli subteretes, breviter hirsuti. Folia 6 cm. longa, 3 cm. lata, ovato-lanceolata, longe acuminata, coriacea, supra scabrido-

hirsuta, subtus longe hirsuta, nervis 5–6. Petioli 3 mm. Stipulæ 6 mm., extra sparse hirsutæ, bilobatæ, lobis ovatis. Pedunculi steriles graciles, 12 mm., uncinati; pedunculi floriferi 2 cm. Bracteæ 4 mm.; laciniæ lanceolatæ. Capitula sine corollis 8 mm. Corolla 7 mm., glabra. Calycis tubus brevis pilosus; pars superior intus longe pilosa; lobi $1\frac{1}{2}$ mm., lineari-lanceolati, marginibus hirsutis, lobis accessoriis parvis. Capsulæ sessiles. Receptaculum hirsutum. Bracteolæ filiformes.—*U. Roxburghiana*, Korth. Verh. Nat. Gesch. Bot. 172; Hook. f. Fl. Brit. Ind. iii. 32.

MALASIA.—Malacca (Maingay, n. 1686). Singapore (T. Anderson, n. 106). Sumatra (Korthals).

25. UNCARIA PILOSA, *Roxb.*

Ramuli fulvo-pubescentes; internodia 7 cm. Folia 13 cm. longa, 65 mm. lata, elliptico-lanceolata, longe acuminata, submembranacea, supra sparse hirsuta, subtus longe hirsuta, nervis 9. Petioli 5 mm., ochraceo-pubescentes. Stipulæ 8 mm., lobatæ, lobis acutis. Pedunculi steriles arcte curvati; pedunculi floriferi 4 cm., fulvo-pubescentes. Bracteæ 5 mm., duæ stipulaceæ bilobatæ, lobis linearibus. Capitula sine corollis 11 mm. Corollæ tubus 1 cm., sparse hirsutus; lobi extra pubescentes. Stigma 2 mm. Calycis tubi longe hirsuti; lobi 2 mm., lineares, extra pubescentes, superne latiores. Capsulæ 8 mm., sessiles. Receptaculum dense hirsutum. Bracteolæ spathulato-filiformes.—*U. pilosa*, Roxb. Fl. Ind. i. 520; Hook. f. Fl. Brit. Ind. iii. 32. *Nauclea scandens*, Smith, in Rees's Cyclop. xxiv. n. 9.

INDIA.—Kumaon (alt. 2500 ft., Strachey). Gringoleehath (alt. 2500 ft., Madden). Himalaya (alt. 2000 ft., Edgeworth). Sikkim (alt. 2500 ft., Hooker f.); Darjeeling (Clarke, alt. 3000 ft. n. 26578, alt. 5000 ft. n. 26961); Chittagong (alt. 0–1000 ft., Hooker f. & Thomson). Khasia (alt. 3000 ft., Hooker f. & Thomson). Garoo Hills (alt. 4000 ft., Clarke, n. 43105). Assam (Masters). N.W. Burmah (Griffith).

This and the next two species are very similar to the Malayan *U. ferrea* and its allies, but differ from them in the presence of bracteoles and in the sessile capsules.

26. UNCARIA HIRSUTA, n. sp.

Typus (Ford) in Herb. Kew.

Ramuli sparsim hirsuti. Folia 10 cm. longa, 5 cm. lata, ovato-lanceolata, acuminata, coriacea, supra nitida in nervis hirsuta,

subtus longe hirsuta, nervis 9–11 ferrugineis. Petioli 5 mm. Stipulæ 6 mm., bilobatæ, marginibus hirsutis. Pedunculi 4 cm., hirsuti. Bracteæ 5 mm., basi connatæ. Capitula sine corollis 2 cm. Corollæ tubus 1 cm., superne pubescens; lobi extra hirsuti. Stylus 15 mm.; stigma 2½ mm. Calycis tubi pars superior 2 mm., angusta; lobi 2 mm., lineari-lanceolati, densi hirsuti, superne angustiores. Bracteolæ 6 mm., spathulato-filiformes, superne hirsutæ.

CHINA.—Lautao Islands (Ford).

27. UNCARIA TONKINENSIS, n. sp.

Typus (*Balansa*, n. 635) *in Herb. Kew.*

Internodia 5 cm., pubescentes. Folia 9 cm. longa, 45 mm. lata, elliptica, acuminata, submembranacea, nervis 8, supra et infra sparse pubescentia. Petioli 5 mm. Stipulæ 5 mm., bipartitæ; lobi lineares acuti. Pedunculi steriles 12 mm.; pedunculi floriferi 4 cm. Bracteæ 3 mm. Calycis lobi 1 mm., lineares. Capsulæ 5 mm.

TONKIN (Balansa, n. 635).

The specimen from which the description is taken has young buds and fruit but no flowers.

PLATE 4.—19. Bracteole. 20. Fruit.

28. UNCARIA SINENSIS, *Hav.*

Typus (*Henry*, n. 4501 A) *in Herb. Kew.*

Ramuli subteretes; internodia 75 mm. Folia 135 mm. longa, 75 mm. lata, ovata vel ovato-lanceolata, acuminata, membranacea, glabra, nervis 8. Petioli 1 cm. Stipulæ 5 mm. longæ, 8 mm. latæ, integræ, basi auriculatæ. Pedunculi steriles 15 mm., complanati, recurvi; pedunculi floriferi 6 cm., graciles. Bracteæ 3 mm., basi sæpe connatæ. Capitula sine corollis 11 mm. Corollæ tubus 8 mm., glaber; lobi 1 mm., lineares, lobis secundariis sæpe additis. Receptaculum hirsutum. Bracteolæ spathulato-filiformes.—*Nauclea sinensis*, Oliver, in Hook. Ic. Pl. t. 1956.

CHINA.—Ichang (Henry, n. 4501).

29. UNCARIA RHYNCHOPHYLLA, *Miq.*

Internodia 45 mm. Folia 9 cm. longa, 4 cm. lata, elliptica, acuminata, basi attenuata, glabra, nervis 5–6. Petioli 12 mm. Stipulæ 4 mm., bilobatæ, lobis filiformibus. Pedunculi steriles 12 mm., complanati; pedunculi floriferi 35 mm., graciles. Bracteæ 4 mm., angustæ. Capitula sine corollis 6 mm. Corollæ tubus 7 mm., glaber. Stigma 2 mm. Calycis tubus hir-

sutus; lobi 1 mm., oblongi. Capsulæ 4 mm., sessiles. Bracteolæ spathulato-lineares.—*Uncaria* (*Nauclea*?) *rhynchophylla*, Miq. Ann. Mus. Lugd.-Bat. iii. 108.

JAPAN.—(Maximowicz, Siebold).

30. UNCARIA HOMOMALLA, *Miq.*

Ramuli avellanei, pubescentes; internodia 3 cm. Folia 8 cm. longa, 36 mm. lata, elliptico-lanceolata, longe acuminata, subcoriacea, supra glabra, subtus sparse hirsuta; nervis 8, supra depressis, subtus prominentibus fulvis, tribus infimis approximatis, divergentibus, nervulis transversis parallelis. Petioli 4 mm., hirsuti. Stipulæ 4 mm., bifidæ, lobis linearibus hirsutis. Pedunculi steriles 1 cm., compressi; pedunculi floriferi graciles, pubescentes. Bracteæ 2 mm., parvæ. Capitula sine corollis 5 mm. Corollæ tubus 6 mm., sparse hirsutus. Stigma 2 mm. Calycis tubus 1 mm., hirsutus; lobi breves, ovati. Receptaculum hirsutum. Bracteolæ spathulato-filiformes.—*U. homomalla*, Miq. Fl. Ind. Bat. ii. 343; Hook. f. Fl. Brit. Ind. iii. 30. *U. pilosa*, Wall. List, n. 6108 c.

N.E. INDIA.—Jyntea Hills (Wallich, n. 6108 c).

MALASIA.—Sumatra (Teysmann).

31. UNCARIA LÆVIGATA, *Hook. f.*

Ramuli sparsim hirsuti; internodia 4 cm. Folia 10 cm. longa, 5 cm. lata, elliptica, acuminata, subglabra, nervis 6. Petioli 6 mm. Pedunculi steriles 12 mm.; pedunculi floriferi 5 cm. Bracteæ parvæ, connatæ. Capitula sine corollis 9 mm. Corollæ tubus 8 mm., glaber. Calycis tubi pars inferior compresso-angulata, pars superior dilatata intus glabra vinosa, limbo subintegro. Capsulæ 8 mm., sessiles. Receptaculum dense hirsutum. Bracteolæ spathulato-lineares.—*U. lævigata*, Hook. f. Fl. Brit. Ind. iii. 30; Wall. List, n. 6111.

INDIA.—Khasia (Lemann, n. 297; Griffith, alt. 1000 ft.; Clarke, n. 45023). Manipur (alt. 5000 ft., Watt, n. 7296). Tenasserim (Falconer).

32. UNCARIA SESSILIFRUCTUS, *Roxb.*

Internodia 5 cm., subglabri; nodi hirsuti. Folia 11 cm. longa, 6 cm. lata, elliptico-obovata, abrupte obtuse acuminata, coriacea, glabra, subtus glauca, nervis 5. Petioli 6 mm. Stipulæ 7 mm., bifidæ, lobis linearibus. Pedunculi steriles complanati; pedunculi floriferi 5 cm., sæpe ramosi. Capitula sine corollis 8 mm. Corollæ tubus 8 mm., glaber; lobi intus pilosi. Calycis tubi pars inferior hirsuta, pars superior cupularis extra hirsuta intus

glabra, vinosa; lobi breves obtusi. Capsulæ 11 mm., sessiles. Receptaculum hirsutum. Bracteolæ spathulato-filiformes.—*N. sessilifructus*, Roxb. Fl. Ind. i. 520; Hook. f. Fl. Brit. Ind. iii. 30. *Nauclea scandens*, Roxb. MSS., Ic. Ined. no. 1218 in Herb. Kew.

INDIA.—Nepal (Scully). Sikkim (alt. 2500 ft., Hooker f.). Silhet (Hooker f. & Thomson). Bhotan (Griffith, n. 2124, alt. 2000 ft.; Clarke, nn. 26441, 27980). Cachar (Keenan). Assam (Griffith, Jenkins). Chittagong (Hooker f. & T. Thomson).

S.E. ASIA.—Tonquin (Balansa, n. 2677).

33. UNCARIA TOMENTOSA, *DC.*

Ramuli olivacei; nodi pubescentes; internodia 6 cm., subglabri. Folia 12 cm. longa, 65 mm. lata, ovata vel elliptica, breviter acuminata, coriacea, supra glabra, subtus glauca in nervis ferrugineo-hirsuta, nervis 10, nervulis transversis parallelis. Petioli 14 mm. Stipulæ 8 mm., integræ, obtusæ, castaneæ, subpersistentes. Pedunculi steriles 1 cm., spinosi; pedunculi floriferi sæpe ternatim ramosi. Capitula sine corollis 7 mm. Corollæ tubus 5 mm., extra tomentosus. Stigma 1 mm., ovoideo-clavatum. Calycis ferrugineo-tomentosi, tubi pars superior cupularis; lobi breves obtusi. Bracteolæ filiformæ.—*U. tomentosa*, DC. Prod. iv. 349. *U. surinamensis*, Miq. in Linnæa, xix. 129. *Nauclea aculeata*, H. B. K. Nov. Gen. et Sp. iii. 382. *N. tomentosa*, Willd. in Roem. et Schult. Syst. v. 221. *N. Chinchonæ*, DC. Prod. iv. 347. *N. polycephala*, A. Rich. in Mém. Soc. Hist. Nat. v. 289. *Cinchona globifera*, Pavon, ex DC. Prod. iv. 349. *Ourouparia polycephala*, Baill. in Bull. Soc. Linn. Paris, i. (1879) 229.

AMERICA ÆQUINOCTIALIS. — Nicaragua (Tate, n. 387). Trinidad (Lockhart). Surinam (Splitgerber).

34. UNCARIA GUIANENSIS, *J. F. Gmel.*

Ramulorum nodi interdum hirsuti; internodia 5 cm., glabri. Folia 10 cm. longa, 6 cm. lata, ovata, acuminata, basi in petiolos aliquando decurrentia, coriacea, glabra, nervis 6–7. Petioli 2 cm. Stipulæ 12 mm., oblongæ. Pedunculi steriles uncinati vel spinosi; pedunculi floriferi 5 cm., terminales et axillares. Bracteæ 6 mm., integræ. Capitula sine corollis 18 mm. Corollæ tubus 8 mm., ochroleuco-villosus. Stigma 1 mm., ovoideo-clavatum. Flores pedicellati. Calyx ferrugineo-pubescens; pars inferior 2 mm., pars superior 4 mm., infundibuliformis; lobi breves. Capsulæ

hirsutæ, longe pedicellatæ. Bracteolæ 3 mm., filiformes.—*U. guianensis*, J. F. Gmel. Syst. Nat. (1791) ii. 370. *U. aculeata*, Willd. in Usteri, Del. Opusc. Bot. ii. p. 200 (1793). *Ourouparia guianensis*, Aubl. Pl. Guian. (1775) i. 177.

AMERICA AUSTRALIS CALIDIOR.—Trinidad (Crüger). Orinoco River (Spruce, nn. 3221, 4851). British Guiana (Appun, n. 360). Surinam (Hostmann, n. 610). Cayenne (Martin). Para (Spruce, n. 179). Brazil (Burchell, nn. 8458, 9670). Bolivia (alt. 2000 ft., Rusby, n. 2104).

Species a me nondum visæ.

UNCARIA NEMOROSA, *Korth.*

Folia 14 cm. longa, 9 cm. lata, rotundato-ovata, breviter acuminata, basi subcordata, supra glabra in nervo medio pubescentia, subtus hirsutiuscula. Petioli 5 mm., semiteretes, supra pilosi, subtus pubescentes. Stipulæ ovatæ, profunde bifidæ; laciniæ lanceolatæ, supra glabriusculæ, subtus basi fusco-pilosæ. Pedunculi compresso-tetragoni, fusco-pubescentes. Bracteæ pubescentes, lobis lanceolatis acuminatis.—*U. nemorosa*, Korth. Verh. Nat. Gesch. Bot. p. 166.

SUMATRA (Korthals).

UNCARIA BERNAYSII, *F. Muell.*

Folia 18 cm. longa, 13 cm. lata, subovata, breviter acuminata, basi rotundata, glabra, submembranacea, breviter petiolata, nervis 10. Stipulæ bifidæ. Pedunculi 5 cm., inferne glabri, superne pubescentes. Bracteæ brevissimæ. Calycis tubus sericeus; lobi 3 mm., lineari-oblongi. Capsulæ 22 mm.—*U. Bernaysii*, F. Muell. in Austral. Journ. Pharmac., Feb. 1886.

NEW GUINEA.

Species a genere Uncariâ *exclusæ.*

U. cirrhiflora, Roxb. Fl. Ind. i. 520, omnino nebulosa.

U. eurhyncha, Miq. Fl. Ind. Bat. Suppl. 539, sine floribus ex exemplo in Hb. Kewensi conservato a Miquel communicato, est *Nauclea oxyphylla*.

U. grandifolia, Baker, in Kew Bull. no. 109, p. 23, est *U. pedicellatæ* inflorescentia, foliis alienis admixtis.

U. inermis, Willd. in Usteri, Delect. Opusc. Bot. ii. p. 199 (1793), est *Mitragyna africana*.

U. paucinervis, Teysm. et Binn. Cat. Hort. Bog. p. 117, est nomen nudum.

U. Wallichii, Korth. Obs. de Naucl. Ind. p. 17, est nomen nudum.

There is a flowerless plant from Brazil (*Burchell*, n. 8234) in several herbaria; it may belong to this Tribe, but if so it will probably be a new genus.

Another plant, which is represented in some herbaria by flowerless specimens (*R. Brown*, April 1803) from Timor, may belong to this Tribe. The leaves are 29 cm. long and 12 cm. broad, oblong, rounded at both ends, hairy below. Petioles 2 cm. Stipules 25 mm., oblong, flat, but cohering at the bases.

The following species was placed by M. Baillon in the Tribe, but more from a difficulty in finding a natural place for it than from its resemblance to any others of the Tribe; its flowers are unknown.

PARACEPHAËLIS TILIACEA, *Baill.*
Typus (*Pervillé* n. ?) *in Herb. Paris.*
Arbuscula 3 m. Folia 9 cm. longa, 8 cm. lata, cordata, acuminata, coriacea, supra scabra, in nervis hirsutis, subtus dense fulvo-tomentosa, nervis 4–7, petiolis 15 mm., rufo-tomentosis. Stipulæ 4 mm., interpetiolares, subpersistentes. Ramuli graciles. Pedunculi 25 mm., solitarii, terminales, bracteati. Capitula post anthesin 18 mm., flores pedicellatæ. Bracteolæ 3 mm., sublanceolatæ. Calycis tubus parte inferiore subglobosâ, fulvo-tomentosâ, parte superiore brevi; lobi 2 mm., subtriangulares extra fulvo-tomentosi. Ovarium biloculare, placentis peltæformibus. Semina 6–8, complanata suborbicularia.—*Paracephaëlis tiliacea*, Baill. Adansonia, xii. 316.
MADAGASCAR.—Ambongo (Pervillé).

EXPLANATION OF THE PLATES.

PLATE 1.

Breonia parviflora. Figs. 1–4.

Fig. 1. Plant, natural size; fig. 2, flowers; fig. 3, stigma; fig. 4, ovules. (Figs. 2–4 enlarged.)

Breonia stipulata. Figs. 5–7.

Fig. 5. Portion of plant with inflorescence, natural size; fig. 6, fruit; fig. 7, seed. (Figs. 6 & 7 enlarged.)

PLATE 2.

Nauclea strigosa. Figs. 1–9.

Fig. 1. Plant in bud; fig. 2, the same in flower; fig. 3, flower; fig. 4, calyx; fig 5, stigma; fig. 6, longitudinal section of ovary; fig. 7, fruit, nat. size; fig. 8, the same, enlarged; fig. 9, seed. (Figs. 1, 2, & 7 natural size; the others enlarged.)

PLATE 3.

Nauclea angustifolia. Figs. 1–7.

Fig. 1. Plant in bud; fig. 2, the same in flower; fig. 3, flower; figs. 4 & 5, calyx-lobes; fig. 6, section of corolla; fig. 7, stigma. (Figs. 1 & 2 natural size; the rest enlarged.)

PLATE 4.

Mitragyna macrophylla. Figs. 1–10.

Fig. 1. Flower, natural size; fig. 2, the same, enlarged; figs. 3 & 4, bracteoles; fig. 5, tip of petal; fig. 6, stigma; fig. 7, fruit, natural size; fig. 8, the same, enlarged; fig. 9, section of fruit; fig. 10, seed. (Figs. 1 & 7 natural size; the rest enlarged.)

Mitragyna rubrostipulacea. Figs. 11 & 12.

Fig. 11. Bracteole; fig. 12, calyx. (Both figures enlarged.)

Uncaria Hookeri. Figs. 13–18.

Fig. 13. Inflorescence, natural size; fig. 14, calyx and section of ovary; fig. 15, stigma; fig. 16, fruit, natural size; fig. 17, the same, enlarged; fig. 18, seed. (Figs. 13 & 16 are life-size; the remainder are enlarged.)

Uncaria tonkinensis. (Figs. 19 & 20.)

Fig. 19. Bracteole; fig. 20, fruit. (Both figures enlarged.)

Sarcocephalus esculentus. Figs. 21–24.

Fig. 21. Flowers; fig. 22, section of calyx and ovary; fig. 23, stigma; fig. 24, seed. (All enlarged.)

Adina polycephala. Figs. 25–31.

Fig. 25. Flower; fig. 26, bracteole; fig. 27, calyx-lobe; fig. 28, stigma; fig. 29, fruit; fig. 30, section of ovary; fig. 31, seed. (All enlarged.)

Anthocephalus macrophyllus. Figs. 32–37.

Fig. 32. Stipule, natural size; fig. 33, flower, natural size; fig. 34, the same, enlarged; fig. 35, calyx-lobe; fig. 36, stigma; fig. 37, section of ovary. (Figs. 32 & 33 natural size; the remainder enlarged.)

Anthocephalus indicus. Figs. 38–43.

Fig. 38. Stipule, natural size; fig. 39, flower, natural size; fig. 40, the same, enlarged; fig. 41, calyx-lobe; fig. 42, stigma; fig. 43, section of fruit. (Figs. 38 & 39 natural size; the others enlarged.)

M. Smith del.

J. N. Fitch lith & imp.

1-4. BREONIA PARVIFLORA. 5-7. B. STIPULATA.

M. Smith del.
J. N. Fitch lith & imp.

NAUCLEA STRIGOSA

M. Smith del.

J.N. Fitch lith & imp.

NAUCLEA ANGUSTIFOLIA

The Adhesive Discs of *Ercilla volubilis*, A. Juss.

By J. H. BURRAGE, M.A., Junior Assistant to the Professor of Botany in the University of Edinburgh. (Communicated by Prof. J. BRETLAND FARMER, M.A., F.L.S.)

[Read 18th February, 1897.]

(PLATE 5.)

ERCILLA VOLUBILIS, A. Juss. (syn. *E. spicata*, Moq.), a Phytolaccaceous climber, is a native of Chili, first introduced into this country by Bridges, and hence known also under the name of *Bridgesia*, Hook. & Arn. (non alior.).

Although by no means hardy, it is frequently found in gardens in this country as an ornamental shrub; in sheltered positions it flourishes fairly well, and even bears flowers in exceptionally warm summers. It is usually found in cultivation trained up a flat wall, but this is obviously not its natural habit. If left to itself the branches fix themselves on to any available support by means of adhesive discs, borne immediately above the axils of the leaves.

In the stem immediately opposite the base of the axillary buds there is a break in the continuity of the vascular ring, caused by the departure of the bud-bundles. A number of pith-cells, which occupy the normal position of the bundles at this point, become lignified in precisely the same manner as described in the case of *Manihot Glaziovii*, Muell. Arg.* It is suggested that the lignification of these cells takes place in order to strengthen the stem at this point, but it is equally probable that the cells (the walls of which are deeply pitted) may assist the transpiration current by forming a connecting bridge across the base of the branch †.

The discs which support the stem are, when fully developed, about $\frac{1}{2}$ in. long and $\frac{1}{4}$ in. in breadth, each one converging to a point on the stem above the leaf and sending down a small projection on either side of the base of the petiole, and thus has the appearance of a slightly projecting, heart-shaped shield or disc (fig. 1). It is, however, only those in actual contact with the

* Calvert & Boodle, 'Annals of Botany,' vol. i. p. 58.

† The result of a series of experiments recently made, with the object of tracing the path of the transpiration current, by means of weak solutions of various stains, tended to show that the former is the correct view. In all cases the lignified pith-cells opposite the bud remained unstained, while the normal conducting wood was uniformly coloured.

support that attain these dimensions, although mere proximity encourages the formation and partial development of the discs. On branches which project freely into the open they are very small or altogether absent. The size of the organs is considerably modified by surrounding conditions—a damp position favouring their growth to a considerable extent, even when quite removed from proximity to a support. A warm sheltered position also influences their development. Thus, in a specimen growing on the outside of a wall of a forcing-pit in the Royal Botanic Garden, Edinburgh, the discs were largely developed, occurring in various sizes just above the insertion of most of the leaves; while in specimens at Kew and Oxford, in more exposed situations, they were absent except where in absolute contact with, or quite near to, the support.

When the disc is in contact with a support the leaf cannot occupy a normal position, but the lamina is brought out into the open by means of the 'twisting' of the petiole.

Development.—The primary divisions in the development of the disc are initiated at an early stage of the bud. The organ is formed by division and subsequent growth of the cortical cells of the stem, and possesses no definite growing-point, as in the case of a lateral root. Tangential divisions first appear in the layers immediately below the epidermis, just above the axil of the leaf. Similar divisions spread gradually in the subepidermal layers, towards the apex of the stem, and laterally. At the lowest point irregular divisions occur in the deeper cells of the cortex, which become divided up to form a strand of merismatic cells connecting the outer layers with the procambial strand.

As the result of these tangential divisions there is formed, immediately below the epidermis, a layer of columnar cells (Pl. 5. figs. 2 & 3). The latter are uniform in size, larger and much more elongated than those below. They possess a large nucleus, and appear, in all respects, very similar to the cells of the epithelial layer of many secreting glands. Towards the centre the cells divide, forming a double layer. The second layer is not continuous over the whole surface, being always absent at the margin of the protuberance, and only irregularly formed in central positions (Pl. 5. fig. 2 *a*). In the median line of that part of the protuberance nearest the leaf a series of elongated cells are formed, passing in a radial direction from the procambial strand to within three or four layers of the columnar

cells. These eventually become the connexion between the vascular tissue of the disc and that of the stem (fig. 3). By irregular divisions and increase in length, similar elongated cells are formed in a plane at right angles to the connecting cells, thus forming a flattened plate running through the projection in all directions in a plane parallel to its free surface (fig. 4). These elongated cells are, for the most part, gradually differentiated into tracheides with scalariform thickenings. The vascular plate thus formed is thicker towards the centre, becoming thinner as the periphery of the projection is reached. The vascular tissue of the disc is thus connected with that of the stem at a point above the axillary bud, where a plexus is formed abutting on the lignified pith-cells, previously described (fig. 4). The cells immediately above and below the vascular plate of the disc meanwhile continue to divide and increase in size. The resulting pressure from within ultimately effects the rupture of the epidermal layer, which thus is broken up, and eventually becomes exfoliated. The central columnar cells elongate rapidly, and, after the disappearance of the epidermis, they develop into hairs. The formation of hairs spreads from the central position gradually over the whole surface of the disc, thus completing the disruption of the epidermis, some of the cells of which are carried up on the apices of the hairs (see Pl. 5. fig. 5, *e*). This kind of subepidermal origin of hairs is unusual * ; for example, in the "suckers" of *Ampelopsis* †, which have several points in common with the discs of *Ercilla*, the hairs spring from the epidermis alone, and not from a definite layer previously laid down beneath it.

If at this point the disc be in contact with a wall or other suitable support, the whole organ increases in area and thickness, and the hairs grow to considerable length. The latter, coming in contact with the wall, adhere to it, in the first instance

* Some time after this paper was sent in, Van Tieghem published in 'Le Journal de Botanique' (February 1st, 1897) a paper entitled "Origine exodermique des poils post-staminaux des sépals chez les Santalacées," in which the formation of hairs from a subepidermal layer, and the consequent exfoliation of the epidermis, is described. The development appears to be precisely similar to that described above for the hairs of the discs of *Ercilla*. Hitherto no similar subepidermal origin of hairs has been observed, and Van Tieghem cites the case of the Santalaceæ as unique in this respect.

† A. von Lengerken, "Die Bildung der Haftballen an den Ranken einiger Arten der Gattung *Ampelopsis*." Bot. Zeit. 1885.

by means of a mucilaginous secretion, such as described in the case of *Ampelopsis** and of many adhesive roots of Aroids, *Ficus* sp. &c.†

This secretion takes place only at early contact, when it protrudes from the apices of the hairs and can be stained pink by the action of corallin. The hairs increase in length, forcing their way into crevices, and apparently eating into the substance of the support, probably by means of a solvent secretion. The walls of the hairs become considerably thickened, the protoplasm at the same time being gradually diminished, possibly being used up in forming the extra thickening of the wall. The cellulose wall is now gradually cuticularized, the cuticularization increasing as the disc grows older. The thickening of the walls gives considerable strength to the hairs, which bind the branch close up to the support, the disc adhering with considerable tenacity. If the latter be torn away, small disorganized particles of the support are found embedded among the mass of hairs.

Secondary changes in the Disc.—The disc does not remain long in this condition, as changes soon occur which modify the nature of its structure. The walls of the cells immediately below the hairs become gradually suberized, down to within three or four cell-layers of the vascular tissue. In spite of this, the peripheral cells retain their protoplasmic contents for some time, eventually losing them, but retaining their original contour by reason of the thickened walls.

A little later there appears in the cells below the corky layers, and just outside the plate of tracheides, a *cambium* (Pl. **5**. fig. 6,*c*), which forms a definite periderm of three or four rows of cells. This completely isolates the outer part of the disc from the vascular tissue.

At this stage the disc is made up of the following tissues:—(1) somewhat collapsed, empty hairs, with thickened walls, below which are (2) several irregular layers of corky cells, in which raphides frequently occur. Still more internally lies (3) a regular periderm, springing from a phellogen which is separated by (4) three or four layers of small-celled parenchyma from (5) the plate of tracheides. The large parenchymatous cells below

* Darwin's 'Climbing Plants,' p. 147.

† F. A. F. C. Went, "Ueber Haft- und Naerh-Wurzeln bie Kletterpflanzen und Epiphyten." Ann. du Jardin bot. de Buitenzorg, vol. xii. (1894).

the vascular tissue of the disc gradually merge into those forming the cortex of the stem (fig. 6). The fact that the discs remain functional after the formation of a complete periderm seems to show that it is not merely the casting off of the disc, as is the case in those tendrils of *Ampelopsis* which do not come into contact with a support.

The Formation of Roots on the Disc.—Some discs growing in a moist atmosphere, after their periderm is completely formed, give rise to small *roots.* These arise from the cells below the cork cambium, and force themselves out through the corky tissue above (fig. 7). In structure they resemble normal roots, having a root-cap and a well-developed large central cylinder which is in connexion with the vascular tissue of the disc, and thus indirectly with that of the stem. They entirely differ from the normal root, however, in that the outer layers of the root-cap and the whole of the cortical cells have thick suberized walls. This suberization takes place very early, so that the root is always completely surrounded by several layers of corky cells. The majority of the discs do not bear roots at all, while in some cases as many as six project from one disc. They grow to little more than half an inch and then remain stationary. There is no sign of these roots assisting in any way towards the support of the stem, and it is difficult to imagine what function they could possibly perform.

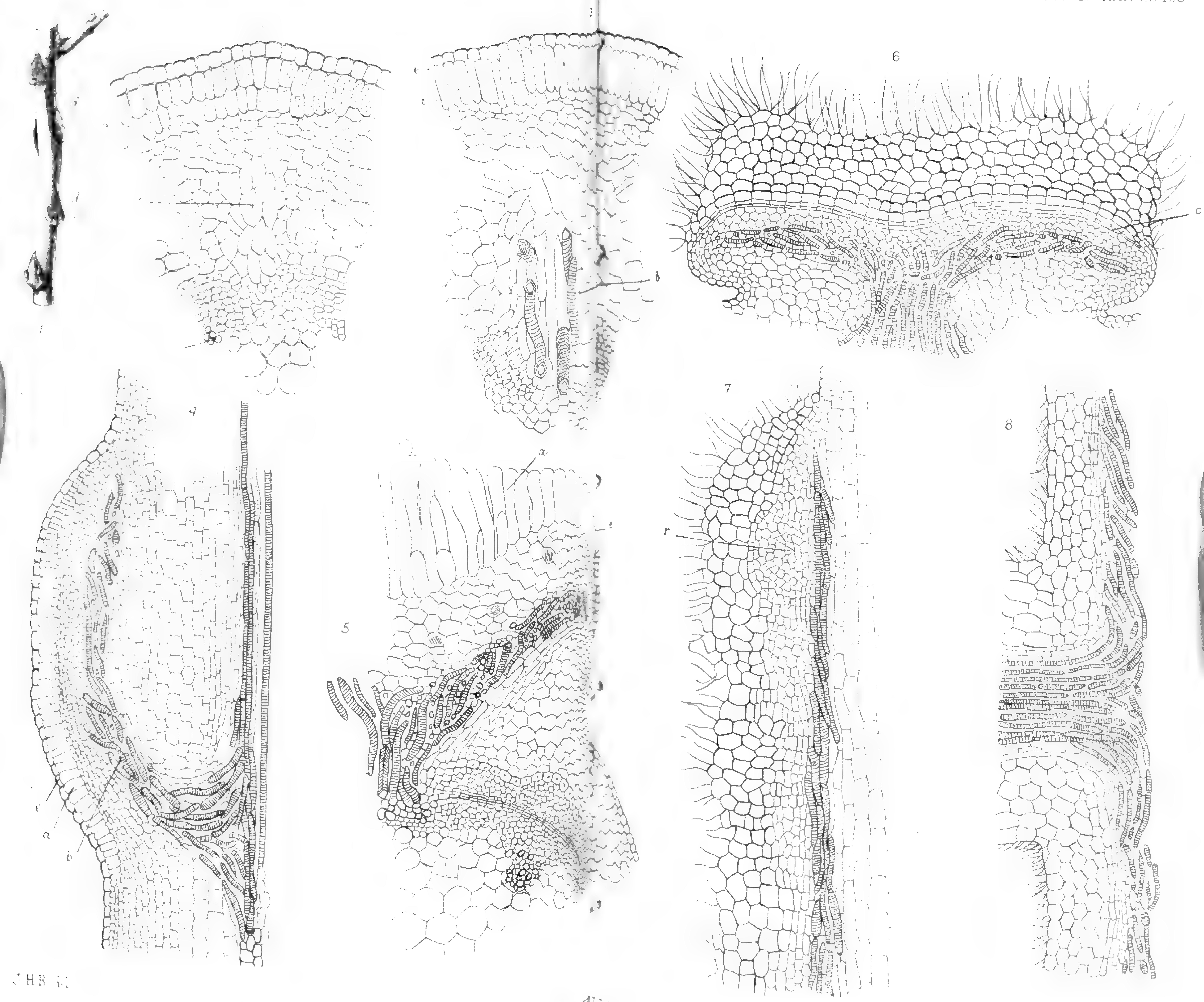
In time, as the stem becomes thicker and heavier, the disc ceases to function, and by the friction of the branch against the support, the remains of the hairs and most of the original outer cells are worn away, down to the periderm formed by the cork cambium. Thus, on an old part of the stem, the position of the disc is indicated by a brown scar, which projects very little from the surface of the stem.

Rudimentary and Abortive Discs.—In addition to the normal functional discs there are many others, of no apparent service to the plant, in various stages of development and degeneration. The conditions governing the formation of these rudimentary discs vary. As already suggested, absolute contact seems to be necessary for full development, although proximity to the support stimulates growth to a large extent. On the other hand, discs on branches which grow away from the support become proportionately smaller the farther they are removed from it. Since the leaves are arranged in a $\frac{2}{5}$ spiral, and the internodes are compara-

tively short, a large number of functionless discs are only separated from the support by the thickness of the stem. Those discs on the other side of a stem which is in contact with a surface are often nearly as large as those which actually fasten the branch to it. In this case the development and subsequent changes proceed very similarly in both, with the exception that, unless in a very damp position, the hairs of the disc not in contact are shorter, and the formation of the cork cambium takes place much earlier than in those discs applied to the support. It is difficult, however, to decide how much of this development of functionless discs is due to the action of moisture. In all cases the first stages of development are initiated much later than in the normal disc, and the further growth is much more irregular. In some the formation of hairs is confined to a small central area, the epidermis remaining intact over the greater portion, which projects but little from the stem. Small discs are occasionally formed on branches some way removed from any support, in which the hairs are fully developed—evidently stimulated to growth by moisture. Similarly, discs in various stages of corky degeneration may be found, but in all cases smaller than those near to the support. In some semi-developed discs the walls of the columnar cells become suberized, the epidermis still remaining above, consisting of empty cells with thickened walls. In this case the epidermis has probably been severely strained by the pressure from the growing tissues beneath it, which necessitates the formation of a corky layer, as a check to evaporation. On branches excluded by position from proximity to a support or a damp medium, there are no traces of discs in any stage of development.

The position of the discs in the axils of the leaves is apparently ill adapted for purposes of climbing. The twisting of the petiole brings the blade of the leaf into a more favourable position for the performance of its functions, but even then, in the case of a flat surface, some four out of six of the discs are of no use in supporting the plant, since the leaves are arranged in a $\frac{2}{5}$ spiral. The general appearance of the plant suggests a scrambling nature, and one well adapted for creeping among loose stones or climbing over larger shrubs.

The vertical position of many of the leaves, their funnel-shaped lamina and grooved petiole with expanded sheath, suggest the possibility of the discs absorbing water, which must necessarily



J.H.B. del.

J.N. Fitch lith.

ADHESIVE DISCS OF …A VOLUBILIS, A. Juss.

be carried over them when rain falls on to the lamina. Beyond this coincidence, however, there is no evidence of absorption on the part of the discs, and indeed the presence of the cork renders it impossible in the older ones.

Summary.—The results arrived at may be briefly summarized as follows:—The adhesive organs are developed endogenously immediately above the axils of the leaves. Each is made up of a mass of parenchyma, with a central plate of tracheides, in connexion with the bundles of the stem at the base of the disc. Hairs, which force their way into the crevices of the support, are formed from a special layer of columnar cells beneath the epidermis, resulting in the exfoliation of the latter. After a time the walls of the cells in the external layers of the discs become suberized, a periderm being eventually formed from a definite cambium just outside the vascular plate. While absolute contact is necessary for complete development, discs of various sizes may occur some distance from the support, possibly stimulated to growth by a moist environment. A few discs give rise to small roots, but, as the walls of the cortical cells are invariably suberized, they cannot function in a normal manner.

While there is no evidence to indicate that the discs function other than as climbing organs, at the same time a comparison with parasitic organs, such as those of *Cuscuta*, suggests the possibility that the discs are not far removed from acting parasitically.

I have to thank the Council of the Royal College of Science, South Kensington, for granting me the use of a table in the Huxley Research Laboratory, where this work was completed. I am also indebted to Professor Bayley Balfour for suggesting the investigation, and especially to Professor J. B. Farmer for his constant supervision during its progress.

EXPLANATION OF PLATE 5.

[a & a_1=columnar cells; b=strand of elongated cells; c=cork cambium; d=the disc; e=epidermis; l=foliage-leaf scar; s=vascular ring of stem.]

Fig. 1. Portion of stem with leaves removed, showing discs (about natural size).

Fig. 2. Transverse section of part of stem, illustrating development of disc.

a & a_1. Columnar cells, which give rise to hairs.

b. Elongated cells, eventually forming the vascular connexion with the xylem of the stele.

Fig. 3. Similar section, showing development further advanced.

Fig. 4. Radial section, illustrating connexion of vascular tissue of stem and disc.

Fig. 5. Transverse section, illustrating the formation of hairs from columnar cells and the exfoliation of the epidermis.

Fig. 6. Transverse section through old disc. The outer cells are suberized, and a regular periderm is being formed by a cork cambium.

Fig. 7. Radial section through portion of old disc. At *r* the tissue beneath the cork is giving rise to roots.

Fig. 8. Similar section, illustrating the connexion of the vascular tissue of older root with that of the disc.

On a *Trichoderma* Parasitic on *Pellia epiphylla*. By W. G. P. Ellis, Demonstrator in Botany of the University of Cambridge. (Communicated by Prof. H. Marshall Ward, D.Sc., F.R.S., F.L.S.)

[Read 4th March, 1897.]

(Plates 6 & 7.)

At the Cambridge University Botanic Garden the Liverworts are grown in red earthenware-pans, 12 inches long and 9 inches wide, kept in the Filmy Fern house. Early in May 1896 a disease appeared in one of these pans in which the thallus of *Pellia epiphylla* alone was growing. At one corner of the pan the thallus became diseased, as shown by its colour changing from green to a dull brown; and this browning of the thallus extended centrifugally over the pan during May and June.

I had never before seen nor heard of any special disease of Liverworts. They may often be found more or less covered with species of *Oscillaria*, especially when kept too damp and not sufficiently illuminated; but here was a definite disease, obviously epidemic, and which spread centrifugally onwards with an ever-increasing margin over the pan (compare figs. 1 and 2, reproduced from photographs). Professor Marshall Ward suggested that I should examine this disease, and if possible ascertain to what it was due.

For several days nothing further was observable beyond what has been described above; but on May 14th there appeared near

the margin of the diseased area small white downy patches (Pl. 6. fig. 1) strongly resembling those of *Penicillium* when grown on nutrient gelatine for class-work in the laboratory. One of these patches was carefully teased, and showed a dense mat of septate mycelium from which very numerous aerial hyphæ radiated outwards. Later these patches became bluish, again recalling *Penicillium*; but they then passed through a blue-green colour to a distinct sap-green. A teased specimen (Pl. 7. fig. 26) now showed numerous round greenish spores borne terminally in clusters on the aerial hyphæ, which are therefore the conidiophores arising from the septate mycelium. These spore-bearing patches occurred chiefly, though not exclusively, at the margin of the diseased thallus, though I never found them at that corner of the pan where the disease first appeared.

My next step was to determine whether or not a similar mycelium was present in the thallus; and, if present, whether it was intracellular or intercellular.

The structure of *Pellia* thallus is easily made out from a transverse section. The extreme edge is usually only a single cell in thickness, though occasionally a double layer may be found. Proceeding towards the "midrib," the thickness increases to three layers of cells, of which the central layer is of large cells, covered above and below by the smaller, flatter, superficial cells that contain a larger number of chlorophyll corpuscles. At the midrib there may be as many as fourteen layers of cells, all containing a certain number of chloroplastids, which, however, are specially abundant in the upper superficial cells and those immediately below. At this region many of the cells of the lower superficial layer are prolonged into brown rhizoids.

The progress of the disease could be easily traced in each piece of thallus. The oldest part was brown, but towards the apex the normal green colour of the thallus persisted. So general was this appearance and so suggestive of the entrance of the fungus by the older part of the thallus, that I could not help wondering as to its precise significance. Does the fungus live as a saprophyte on the dead thallus, and thence extend as a parasite into the living tissues? or is this appearance associated with the fact that rhizoids are not yet developed at the apical parts, and is it by them that the fungus enters? Such questions I hoped to be able to answer as the investigation proceeded.

I cut sections through the boundary-line so as to include in the section diseased tissue and a part of the apparently healthy thallus. In these sections I found the septate mycelium in the cells; and while some segments were full of granular, much vacuolated protoplasm, the other segments contained little, if any (see figs. 16–17).

As the diseased area extended over the pan, new white patches appeared, always at some distance—as a rule about an inch—behind the margin, the intervening zone being occasionally covered (fig. 2) with a white cobweb-like mycelium, similar in structure to that contained in the sections of the thallus. In all cases these patches underwent the change in colour from white, through blue-green, to sap-green. On May 25th zones were well shown on the pan; thus white spore-clusters appeared an inch or an inch and a half behind the margin of the diseased area, the intervening zone being covered with mycelium; green spore-clusters formed a zone further back, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches from the margin, and hence about an inch from the white-patch zone. Thus it seemed that conidia were produced only when the mycelium had obtained sufficient nutriment from the cells of the host which had been killed by it. This appearance of zones was by no means constant: in other words, the period usually required for the completion of the sap-green spore-clusters—eight days—was not invariable; and hence later on white, bluish, and green clusters were much closer together. In July, when almost the entire area was involved in the disease, green patches might be found almost at the margin of the diseased area; but by this time the apparently dead thallus first diseased had commenced to grow again from certain points not really killed, as will be described later.

The plan adopted was to first isolate the fungus, then to cultivate it, and next to show how it infected the host; and the following pages are based on the experiments conducted with these objects in view.

I may say at once that the septate mycelium and the conidia indicated that the fungus was the conidial phase of some Ascomycete, whose resting stage I have not yet obtained. In the absence of phases other than conidial an exact identification is hardly possible; but the fungus seems closely allied to, if not indeed identical with *Trichoderma*, the conidial stage of a

Hypocrea *, long known as a saprophyte, but in the present instance apparently associated with a definite disease.

I removed a few spores from spore-clusters on the host by means of freshly drawn glass needles, and sowed them in hanging-drops of a nutrient solution made by boiling pieces of thallus and filtering-off and sterilizing the extract thus obtained. (I had already made trial cultures, and had found that the spores grow readily in drops of the juice squeezed out of the crushed thallus, diluted, but not sterilized.) Before entering into details I may say that other cultures were made in flasks, tubes, and hanging-drops of sterile

(1) cold-water extract of the thallus;
(2) boiling-water „ „
(3) nutrient gelatine, consisting of (1) containing gelatine;
(4) „ „ „ (2) „ „

In addition I sowed spores, taken from the spore-clusters on the host, on fresh, healthy pieces of thallus, some of which were kept in the dark room, while others were allowed to remain as controls in the laboratory. Finally, I sowed spores from pure cultures on pieces of thallus, some from the Filmy Fern house and in other cases on thallus obtained from a brook in the neighbourhood, where it grows wild and whence the original stock of thallus had been brought.

My method of preparing the medium was as follows:—Pieces of thallus were thoroughly pounded in an earthenware mortar with a small quantity of clean white sand, and the whole then boiled in a beaker for about half an hour; then strained and filtered and added to well-soaked gelatine. The resulting nutrient gelatine was filtered and sterilized. Two-ounce flasks were prepared with a layer of nutrient gelatine about 1 cm. deep; and test-tubes containing 3–5 c.c. were, after complete sterilization, inclined, so that at the final cooling as large a gelatine surface as possible was obtained. Both flasks and tubes were infected by means of freshly drawn glass needles, and a daily record kept of all changes observed. The normal course of events was as follows:—In about 24 hours the point of infection could be

* For *Trichoderma* see Saccardo. Sylloge, vol. iv. p. 59; Rabenh. Krypt.-Flora, Nos. 2921–2926; Tulasne, 'Select. Fung. carp. vol. iii. Tab. iii.; Schenk's 'Handbuch,' iv. p. 727; Harz, in Bull. Soc. Imp. des Nat. Mosc. xliv. p. 116; Berkeley's 'Outlines,' p. 357; Cooke's 'Brit. Fungi,' vol. ii. p. 774; Massee's 'Fungus Flora,' iii. p. 295.

readily identified as an opaque cloudy spot on the clear jelly. This area extended, and with a lens a mycelium could be made out which penetrated deeper and deeper into the jelly, so that it appeared to contain a sunk cup filled with mycelium. The gelatine was liquefied in the neighbourhood of the mycelium, and beyond the circular margin of the liquid the mycelium could be seen growing in, and at the surface of, the gelatine until the whole contents of the tube or flask were liquid supporting a mat of mycelium at its surface. This liquefaction extended during the week, and by the tenth day there appeared on the surface of the gelatine white patches, at first very small, then about the size of small pin-heads, and growing until they were 2 mm. or more in diameter, still retaining their original white colour. In about a fortnight these white patches became yellowish in colour, deepening to a dull orange and then to a dirty grey, which became bluish and greenish; later the patch presented a green centre surrounded by a white or greyish margin. When teased, they resembled the patches formed on the host in all essential particulars. Later on, that is to say by the end of the third week, the patch had become quite brown, though the margin remained, as a rule, the dull grey of the whole of the younger patch. No further change was noticed during eight weeks beyond the fact that fresh clusters appeared to grow out from the margin, so that in old cultures the outline of the cluster was very irregular. The above differed somewhat from the formation of the clusters on the host itself. This is well shown by a comparison of two cases. In case (1) a piece of diseased thallus was isolated and kept covered in a glass dish on the laboratory-bench among the flask- and tube-cultures, and therefore exposed to the same conditions of temperature, &c. On Monday, June 1st, mycelium could be faintly seen growing over the surface, recalling the cobweb appearance mentioned earlier (p. 104). On Thursday, June 4th, the white patches appeared and were turning blue on the next day, and by Saturday, June 6th, a greenish tinge was observable, and they had attained their normal sap-green colour by Tuesday, June 9th. In all cases the outline of the patch on the host is more definite than in gelatine cultures. In case (2) a tube was infected at 11.40 A.M., Friday, June 5th, and the area of infection was well shown at 7.0 A.M. of the next day. By 7.30 A.M. on Thursday, June 11th, the gelatine was liquid, and numerous hyphæ appeared on its surface producing a "mouldy

appearance," well shown at 7.30 A.M. on Saturday, June 13th. At 6.48 A.M. on Monday, June 15th, two small white patches appeared and increased in size during the week, new and similar patches appearing day by day and similarly enlarging. By 6.45 A.M. on Monday, June 22nd, the centre of the patch had acquired a distinctly green colour, which darkened until at 6.50 A.M. on Friday, June 26th, it was quite brown and underwent no further change in colour.

From these two instances spore-formation seems to occupy more time in gelatine growths than on the host. This seems to be due only to the fact that in the host there is a speedy exhaustion of the material available, whereas in the cultures there is a much greater supply: hence, while a single cluster appears on the host, successive clusters appear on the gelatine.

Hanging-drop cultures proved more instructive than flask- and tube-cultures. I proceed thus in making them:—I heat a slide in a Bunsen-flame to clean and sterilize it; I then take a glass ring and heat it, and allow one edge to just touch the surface of some boiling paraffin. I then place the ring on the slide, and let the cell thus formed cool. The rings were cut from hard glass tubing about 15 mm. outside diameter and 9 mm. inside; both surfaces were ground and well polished; so that I had short lengths of the tubing 4 mm. long. I now take some well-cleaned, thin, circular cover-slips and heat them between strips of mica in the Bunsen-flame, and let them cool. I place a drop of sterile nutrient gelatine (p. 109) in the centre of the cover-slip, and sow in it a very few spores taken from the top of a spore-cluster with freshly drawn glass needles. I then invert the cover on the cell, in which I have put three or four drops of freshly boiled distilled water; and thus I have a few spores in a small hanging-drop of some medium, growing in a moist chamber. If I wish the culture to last for some days, the cover-slip is sealed to the ring; but otherwise the polished surface of the ring permits of the sufficiently close approximation of the surface of the cover-slip. If I find my culture-drops evaporating or the growth in them seeming to require more moisture, I rest the slide for a minute or two on the tip of my finger, the heat from which vaporizes some of the distilled water, and this vapour is condensed on the cover-slip, and my culture easily and satisfactorily moistened. By the kindness of Professor Marshall Ward, I was also able to use his improved form of cell for hanging-drop

cultures, described in his paper on "Ginger-Beer Plant" (Phil. Trans. 1892).

In a similar way spores were allowed to germinate in hanging-drops of water containing a small piece of *Pellia* thallus; those pieces being selected which were small and narrow and had rhizoids, being in fact the rejuvenation-shoots referred to later on (p. 116). The time required for germination varied considerably. In 65 hours after sowing some of the spores had undergone no recognizable change, others had swollen to double their diameter, and some had put out a germ-tube equal in length to the diameter of the swollen spore (figs. 9–12). And between these extremes all stages might be found in these cover-slip hanging-drop cultures, in which an extract of the thallus was the culture medium used. In nutrient gelatine the resulting hyphæ were much more luxuriant in 42 hours than in the 65 hours above. In one case spores had in nutrient gelatine put out tubes in 19 hours equal in length to twice the diameter of the spore; and in yet another (Thursday, June 25th) spores had germinated and protruded hyphæ in 16 hours with a length of four times the diameter of the swollen spore; this being the most rapid germination observed. In some hanging-drop cultures in which water was the medium used, as much as four days elapsed before the spores had swollen, and in some of these, germ-tubes were put out only after four days more.

It was most interesting to watch the formation of the mycelium in hanging-drops, or perhaps I might call them hanging-films, of gelatine. The germ-hypha or hyphæ branched repeatedly, septa being put in at more or less regular intervals; and the vacuolation of the protoplasm could be easily followed out. In my eyepiece I used a scale each division of which equalled 3·3 μ; and I watched and estimated the rate of growth of the hyphæ, the occurrence of the septa and branches, and other interesting points connected with the formation of the mycelium. Thus on Monday, June 1st, I found a hypha 280 divisions long as a result of 36 hours' growth, and bearing several branches: I watched its tip for some time, and found it to grow at the rate of one division, *i. e.* 3·3 μ, in each minute from 7.18 A.M. to 7.46 A.M., with three exceptions, when it occupied $1\frac{1}{2}$ minutes. The mycelium, the formation of which could be actually watched in these hanging-drops, resembled exactly that obtained by opening gelatine tubes and flasks, and mounting the mycelium growing in

the nutrient gelatine contained in them; and it resembled, too, that taken from the surface of the host or teased out from its tissues, with the exception that the cultivated mycelium had more protoplasm, and looked, generally speaking, plumper than the normal; but that seemed to me quite what might be expected; the occurrence of empty segments was more common, too, in the normal than in the cultivated mycelium. In the hanging gelatine-drop cultures cross connexions were numerous, and in some cases very complex (figs. 31 & 32); but in no single instance did I see anything resembling the formation of *Haftorganen* or "organs of attachment," so common in similar cultures of *Botrytis*. This method of hanging-drop cultures demonstrated especially well the greater luxuriance of the growth in a more nutrient medium. Spores were found to grow better in gelatine consisting of a cold-water extract of the thallus containing gelatine, than in the extract alone, and better still in gelatine containing boiling-water extract and which I call "nutrient gelatine."

After about three days' growth the mycelium in these hanging gelatine drops shows a special form of branching; the terminal hyphæ swell, their protoplasm becomes much vacuolated, and these hyphæ put out a very large number of short thick branches which often give off numerous secondary branches, thus producing a complicated branching to which, from its appearance, the name "coralline branching" has been given (fig. 30). In such cases the cover-slip, when examined with the naked eye or simple lens, presented exactly the appearance of some of the tube-cultures in an early stage when examined from above.

One special advantage of hanging-drop cultures is the elucidation of the formation of the spore-clusters in tube- and flask-cultures. After about eight to ten days' growth there appeared on the cover-slip small white patches exactly similar to those of the gelatine surface in tubes and flasks. Under the microscope these patches were found to be composed of very numerous aerial hyphæ, branching freely, and radiating outwards from a patch of mycelium, which in a day or two became too dense to be made out. On these hyphæ and their branches were produced terminal white and therefore colourless spores, which increased in size and whose wall became much more distinct. Just beneath and to one side of these terminal conidia appeared others, which also increased in size and definiteness of wall (figs. 27, 28, 29), and in

this way were produced clusters of spores like those of figure 26. Spore-formation was in some cases very slow indeed: thus at 6.35 P.M. on Monday, July 13th, I made a sketch of a small part from a hanging-drop culture, leaving the same part in the high-power field. At 6.35 A.M. on the next day, that is to say after twelve hours, I found that the only change was an increase in size of one conidium; no new conidia had appeared. As the spores increased in number the clusters became of course darker, that is to say more opaque, but there was also a change in colour that could be easily made out with the naked eye, and under the microscope was seen to be due to the fact that on approaching maturity the spores themselves acquired a green, a sort of olive-green, colour. Hence the whiteness of the young clusters is merely due to the air entangled between the branching aerial hyphæ; the darkening is due to the increasing density caused by the repeated branching and the interweaving of the branches; the acquirement of the greenish and other tinges is due to the increase in number and the consequent collecting together of the spores and their approaching maturity. In slide-cultures the small clusters did not show the white margin found in tube- and flask-cultures but not found on the host; and this fact may indicate that the occurrence of this margin is associated with the greater supply of nutriment. This idea is borne out by the fact that in tube- and flask-cultures there were commonly produced around this margin new spore-clusters, so that in some cultures the cluster eventually acquired a considerable size and a very irregular shape. In many hanging-drop cultures the spores appeared imbedded in a bubble or drop of liquid, which fluid seemed to disappear when the conidia were green and mature. The spores were certainly distributed *actively*, for, as a rule, they were found adhering to the cover-slip; and were it merely a falling-off of ripened spores, they would have tumbled into the water below, but instead they had been shot upwards and had adhered to the gelatine surface on the cover-slip from which the aerial hyphæ were growing—and therefore downwards; but in no case was the mechanism of the distribution made out, nor could I identify stalks by which the conidia had been attached. Yet the attachment was firm, for spores adhered when material was fixed and preserved in absolute alcohol; and in material that had been teased out and mounted in glycerine they adhered in clusters of from four to eight or ten, and all still attached to the

conidiophore. There was also a distribution on the host, for towards the end of June and onwards the surface of the thallus in the pan seemed to have received a copious supply of "soot dew," but on examination it proved to be only the spores shot off from the clusters and now distributed over the thallus.

In some hanging-drop cultures in which watery extract of the *Pellia* thallus was used as the culture medium, I noticed a striking deviation from the growth described above, and which growth I feel justified, after many cultures, in considering "normal." This deviation occurred some days after germination. Spores were sown in the ordinary manner, and had after some days put out germ-tubes. As they were not in nutrient gelatine, I hardly expected them to produce a large mycelium, but I found that the germ hypha neither branched nor formed septa but that its apex swelled, the contained protoplasm became more granular, and, in fact, a secondary spore (Pl. 7. fig. 19) was produced, like those described by Plowright for uredospores, by Marshall Ward for *Pythium* and *Phytophthora infestans*, and by no means uncommon. I found, too, that these secondary spores might be interstitial as well as terminal (fig. 20): thus in a cover-slip culture of spores in watery extract, I found both terminal and interstitial secondary spores, the latter closely resembling those so copiously formed in the mycelium of *Mucor* when grown for some days on nutrient gelatine. This secondary spore-formation went on also in the gelatine hanging-drop cultures, but only after several weeks, and after the formation of many conidia (see figs. 21–25). The formation appears to me to be associated with deficiency of nutriment, either by its absence from the medium or caused by the exhaustion of the supply by conidia-formation.

A very interesting point to be learned from cover-slip hanging-drop cultures is the fact that, in some cases at least, the spores will not germinate in the absence of a sufficient food-supply, and that in other cases the starved hyphæ are roused into vigorous growth by feeding. Cultures in watery extract were started on May 28th, and by June 11th some showed that the spores had only swollen, and at most a very small proportion on any cover-slip had germinated; in some cases a single spore only had germinated. Some of these cultures were fed with a section of *Pellia* thallus, the remaining cultures acting as controls. In one case the swollen spores put out hyphæ, 50 to 100 divisions

(333 μ) long, in two days; and the result in another instance was striking, a spore about the centre of the section having produced a branched mycelium with a total length of 640 μ, while a spore remote from the section had in the same time produced a single hypha 7 μ long: hence their growth had been arrested by the want of food, but the spores themselves had not been killed. A similar experiment was tried by feeding similar starved cultures with a drop of nutrient gelatine. The result was that in 40 hours after the feeding, some spores had put out hyphæ 2–3–6–12 and 30 divisions or 100 μ long; some had put out two germ-tubes; and some hyphæ had two and three branches; while the cultures serving as controls, *i. e.* to which no gelatine had been added, still had the spores swollen only and no germ-tubes.

Often in gelatine cultures after some days' growth I found the hyphæ becoming much more attenuated and the protoplasm less abundant in the segments, this being also a starvation effect.

I investigated the parasitic phase of this fungus by examining the diseased thallus, and by attempting to produce the same appearance in healthy thallus brought from a distance and showing no trace of the disease. Some such pieces of thallus I infected directly with spores taken from the normal spore-clusters formed on the host, and others with spores from my own pure cultures. Details of these experiments will be given later.

Careful examination of a very large number of sections of the thallus showed that the mycelium was intracellular. Though in several instances it appeared that hyphæ might also be intercellular, yet, as I saw no sign whatever of any haustoria, I feel satisfied that the mycelium is entirely intracellular. The mycelium was most abundant in the superficial cells or those immediately beneath them, though it was by no means rare in the deeper parts of the thallus. In some sections it was very abundant in the neighbourhood of the antheridia, but in other cases there was no preponderance of mycelium in such regions. So very many sections showed hyphæ at the base of the rhizoids, as to raise the question whether the infection of the host was by way of the rhizoids, but I think the balance of evidence is against this idea. In several cases hyphæ were found within the rhizoid passing along towards its tip but not reaching it, and thus growing from the thallus up the rhizoid, rather than having come from an infecting spore. I even tried to get the direct infection of the rhizoids: I mounted small pieces of the thallus bearing

many rhizoids (really the rejuvenation shoots described on page 116) in hanging drops of water containing many spores, and kept them under observation for three weeks, but no single instance did I see of a germ-tube piercing the rhizoid wall, *i. e.* of penetration of the rhizoid wall *from without*. Similar hanging drops well showed the power of hyphæ to penetrate the rhizoid wall *from within*, and to grow out from them, but in this case these hyphæ had been nourished at the expense of the contents of the rhizoid. This question of infection by the rhizoids seemed to me so important that I gave special attention to it. In very many sections I found mycelium at the base of the rhizoids, but I could not follow the hyphæ into contiguous cells. I had been so much struck with the constancy of the progression of the disease from the older and rhizoid-bearing part of the thallus towards the apical region free from rhizoids, and I had so often found in hanging-drop cultures of small pieces of thallus in water that while the spores towards the upper surface had not even swollen, those near the rhizoids had germinated and their germ-tubes had encircled these rhizoids (pointing to some chemotactic influence), that I could not help thinking that, even though I had specially noticed the cobweb-like mycelium on the upper surface of the thallus (see fig. 2), I should find that infection was by the rhizoids, and that the fungus was a saprophyte, which by feeding on the dead rhizoid had become educated up to a parasitic phase and thus enabled to extend to and to kill living cells. But I can find nothing whatever to support this idea of direct infection by rhizoids.

In many hanging-drop cultures of small pieces of thallus in water I had found that its cells were brown near germinating-spores or their germ-tubes, that they resembled in fact cells of the thallus just at the margin of the diseased area: the walls were brown, the protoplasm shrunken, and the primordial utricle collapsed; the chloroplastids had lost their colour and had become massed together. I endeavoured to produce this characteristic appearance of the disease and to locate the exact point of infection. I kept pieces of thallus in small, covered glass dishes, and directly infected them with spores removed from the clusters on the host by freshly-drawn glass needles. Some were kept in the laboratory dark room, while others were left in the laboratory. The thallus became diseased, but no difference in the time required for infection was recognized, the

only difference in fact being that, while in the thallus in light the brown patches of cells produced by the infection were close together, making indeed a continuous though rather diffuse patch, in the thallus kept in darkness such brown cells were more separated, owing possibly to the elongation of the thallus due to the absence of light and the consequent attenuation of its individual parts (see Pl. **6**. figs. 6–8). I carefully sterilized some fine camel-hair brushes by boiling them for some time in a test-tube. I allowed the fine point to just touch the spore-cluster, the spores thus removed being painted on the thallus, and each brush boiled before again being used. This precaution of removing spores only is very necessary because, especially if taken from a culture, a certain amount of some nutrient substance might otherwise be taken, and, as de Bary * has shown, saprophytic fungi started in nutrient solutions may become parasitic. I tried this effect in several cases, and found that where the spores were mixed up with a drop of gelatine before applying them to the *Pellia*, the thallus became diseased much earlier, the infection therefore being hastened by this nursing up of the spores.

The time necessary for the manifestation of the disease as a result of direct infection varied considerably: thus while at the end of May four days (26th to 30th) sufficed for the appearance of the characteristic brown colour of the diseased thallus, towards the end of June fourteen and even sixteen days were necessary for a similar development of the disease. Can it be that this fungus is specially virulent in the early days of its parasitic phase? The original pan seems to point to some such loss of vital activity, for while at an early period the rate of extension of the disease was rapid—the diseased area having increased by an inch radially between Saturday, May 30th, and Monday, June 1st—during July there was very little change in appearance, the fungus in fact seeming to have exhausted itself, and the host actively rejuvenating.

My chief difficulty was the procuring of a section that would show the actual infection of the host. Pieces of thallus were carefully infected with spores only, and after the third day I cut day by day transverse sections of the thallus and horizontal sections, removing the superficial cells so as to try to get the point of infection in section and in surface view. I found that many spores had not germinated by the fourth, eighth, and even fourteenth day, and the irregularity of germination reduced my

* Comp. Morph. & Biol. of Fungi, Mycetozoa, and Bacteria, p. 381.

chance of success. A large number of my sections showed clearly that direct infection had occurred: single isolated cells of the superficial layer presented the characteristic brown collapsed appearance. I could repeatedly trace a hypha from a spore to a browned superficial cell, from which cell I could trace a hypha through the next cell towards the central tissues, but I could not demonstrate the continuity of these two pieces of hypha. I felt perfectly sure that the obtaining of an ideal preparation was only a matter of time; and I continued to cut, mount, and examine in water sections of the thallus that I had infected from the spore-clusters on the host and from tube cultures. At this juncture Professor Marshall Ward advised me to mount my sections in a one-per-cent. solution of potash; and I cannot say too much in favour of such a practice, for I feel confident that much of my labour would have been spared by its use, and I should have thereby saved much time and valuable material.

However, on Tuesday, July 14th, I obtained among many others the preparation shown in Pl. 7. fig. 33, which is specially interesting as the thallus from which it was cut had been infected from a tube-culture. My preparations, therefore, demonstrated the parasitism of the fungus, for I had taken its spores from the host, had cultivated the fungus, and with the spores from a pure culture had been able to infect the host-thallus and to produce on that thallus the appearances characteristic of the disease, and had traced the actual infection of the host through its upper surface. Such infection can only be parasitism. All the cells were alive, the only sign of approaching alteration being the brown tinge of the wall and this due to the enzyme produced by the spore and its germ-tube: there was no nursing of the fungus on dead matter, and I had been very careful to place spores only on the thallus with no admixture whatever of any nutrient material. The thallus remaining after material for sections had been removed was allowed to live on in the laboratory to see if it would show the same macroscopic optical characters of the disease, and whether the disease would spread along the thallus as in the original cases,—and it did so.

I have therefore been able to satisfy myself that a saprophytic fungus has taken on a parasitic phase. It is by no means an uncommon experience. Some three years ago I saw a very good instance of the same phenomenon at the Cambridge Botanic Garden, where spores of *Botrytis*, growing on a dead twig of *Deherainia*, had fallen on to a leaf of *Adriopsis* immediately

below, and had produced on this leaf an appearance that exactly resembled the ravages of a *Peronospora*, but was really due to the parasitic *Botrytis*, which I allowed to form its conidia so as to remove any possibility of doubt.

At or near the growing-points of *Pellia*, and less often on the margin of the browned, apparently dead thallus, there appeared small green outgrowths (Pl. 6. figs. 3, 4, and 5). These grew and produced elongated slender branches of the thallus, forming in fact the rejuvenating shoots that supply such favourable material for sections to demonstrate the direct infection of the host. Anybody who has passed their hand over a close-growing patch of *Pellia* has probably seen thrown off from the thallus small isolated pieces each capable of independent existence and growth, and resembling in fact the buds on *Lycopodium Selago* stem, and the bulbs and bulbils of higher plants. These rejuvenating shoots are probably related to, if not morphologically identical with, these propagative shoots, and were readily produced by keeping a piece of thallus moist in a covered glass dish. They seem to arise from the apical embryonic tissue, but whether such tissue is capable of withstanding the general disease of the thallus I cannot say. May it not indeed involve the whole question of predisposition? for here is an instance of the immunity of vigorous living cells towards a fungus, to whose attacks older, less vital cells have become an easy prey.

I am very glad of this opportunity of acknowledging the very great assistance so kindly given me. To Professor Marshall Ward I am indebted for much information, for suggestions, and help as difficulties arose. I owe thanks also to Mr. R. I. Lynch, F.L.S., Curator of the Botanic Garden, Cambridge, and to his foreman, Mr. G. Lamb, for their kind assistance in so many ways and for providing me with that supply of material in good condition, so essential in any investigations of this kind.

Summary.

The thallus of *Pellia epiphylla* was found to suffer from a disease evidently epidemic in nature, caused by a fungus whose septate mycelium was found in the tissues of the host. The fungus was isolated and found to be the conidial form of an Ascomycete, and from its structure and conidia, and life-history as far as it could be made out, it appears to be similar to, if not identical with, the Trichoderma-phase of *Hypocrea*, but no resting-stage has yet been found. It was cultivated on nutrient

G.P.E del R. Morgan lith

West Newman imp

PARASITE UPON PELLIA EPIPHYLLA

W.G.P.E. del. R. Morgan lith. West, Newman imp.

PARASITE UPON PELLIA EPIPHYLLA.

media, and spores from a pure culture when applied to healthy thallus produced in it a disease like that of the original thallus. By means of sections the direct infection of the host by its upper surface was followed out and the parasitic nature of the fungus established.

EXPLANATION OF THE PLATES.

Plate 6.

Fig. 1. Appearance of a pan of *Pellia epiphylla* on May 14th, 1896. The hole on the side is due to the removal of a sample of the thallus at the margin of the diseased area. From this hole the diseased area extends, and near that margin towards the centre of the pan are several small white spore-clusters in an early stage of development.

Fig. 2. Appearance presented by the pan on June 5th, 1896. The greater part of the area is now involved, and the mycelium is extending over the surface of the part last attacked. On the diseased tissue spore-clusters, both white and green, are numerous, and at the parts first attacked rejuvenation shoots (compare figs. 3 & 5) have appeared.

Figs. 3–5. Examples of the rejuvenation shoots produced on the thallus of *Pellia*, killed by its parasite *Trichoderma*.

Figs. 6 & 7. Pieces of thallus of *Pellia*, showing the small diseased areas produced by brushing spores of *Trichoderma* on the upper surface a fortnight earlier.

Fig. 8. A piece of thallus similarly infected but kept in a dark room for the fortnight.

Plate 7.

Figs. 9–15. Germination of the spores of *Trichoderma*, some with two germ-tubes.

Figs. 16–18. Hyphæ of *Trichoderma*, some segments containing vacuolated protoplasm while other segments are empty.

Figs. 19 & 20. Formation of secondary spores, terminal and interstitial, of *Trichoderma* in cold-water extract of *Pellia epiphylla* thallus, in a coverslip culture two weeks old.

Figs. 21–25. Formation of secondary spores in a gelatine hanging-drop culture of *Trichoderma*, during its fourth week of growth and after the formation of conidia.

Fig. 26. Conidia and conidiophore removed from a spore-cluster of *Trichoderma* grown on the thallus of *Pellia epiphylla*.

Figs. 27–29. Stages in the formation of the terminal conidia of *Trichoderma* in gelatine hanging-drop cultures.

Fig. 30. "Coralline branching" in hanging-drop cultures.

Figs. 31 & 32. "Cross connexions" in hanging-drop cultures.

Fig. 33. A preparation, illustrating the direct infection of *Pellia* thallus by the germ-tube of a spore of *Trichoderma*, and the discoloration of the cell-wall, caused by the enzyme produced by the germinating spores and their germ-tubes.

On the Origin of "Transfusion-tissue" in the Leaves of Gymnospermous Plants. By W. C. Worsdell. (Communicated by D. H. Scott, F.R.S., F.L.S., Hon. Keeper of the Jodrell Laboratory, Royal Gardens, Kew.)

[Read 18th March, 1897.]

There is a species of conducting-tissue occurring in the green parts of certain plants which for long has been known by the name of *transfusion-tissue*. It occurs principally in the leaves of Gymnosperms, but is not exclusively confined to this group of plants. It is found most usually in direct connexion with a vascular bundle, and extending out from this among the cells of the surrounding parenchyma, and consists of tracheides, short and parenchymatous in shape, which are often accompanied by bast-cells. It doubtless serves as a secondary conducting-tissue for those leaves whose vascular bundles are few or widely separated, and are not supplied with a complex system of veins such as is found in Dicotyledonous plants. It is most abundantly represented in the leaves of Conifers, where it is universal; it is also found in the leaves of nearly all Cycads. In these two orders of plants the transfusion-tissue occurs almost always in *lateral* connexion with the vascular bundle. But it is also found in a few genera all round the bundle, in others on the outer periphery of the phloem, and in others again opposite the xylem.

As regards the origin of this tissue there are various views: some consider that it forms part of the conducting-tissues of the vascular bundle to which it is attached; others consider that it belongs to the parenchymatous ground-tissue of the leaf; finally, the French botanist, Van Tieghem, maintains that it is part of the pericycle surrounding the bundle. While the latter view may be perfectly correct as far as the ontogenetic origin of the elements composing this tissue is concerned, my own investigations go to show that, phylogenetically, this tissue has an origin agreeing with that assumed by the first of the above views, viz. from the vascular bundle itself, though in a manner very different from what the authors of this view suspected.

I will first of all describe the structure of a bundle from an ordinary foliage-leaf of a Cycad, so as to pave the way for my subsequent remarks. It is well-known that the vascular bundles of the leaf of Cycads have a structure peculiar to this order and not found in any other living group of plants. Towards the

dorsal (lower) surface of the lamina is placed the phloem; next comes the ordinary xylem, which is formed by the cambium in a *centrifugal* * manner; on the inner side of the secondary wood there may or may not be a few elements of primary centrifugal wood, and then comes the protoxylem, consisting of narrow, elongated, spirally- or reticulately-thickened elements. Further, beyond the protoxylem, *i. e.* between this tissue and the ventral (upper) surface of the leaf, occurs another strand of xylem, primary in origin, and of much greater development than that of the centrifugal wood: this is *centripetal* in development, *i. e.* its elements are formed successively from the protoxylem towards the ventral (upper) surface of the leaf; it is characteristic of the Cycadeæ. In the petiole the structure of the bundles is the same though their orientation is different.

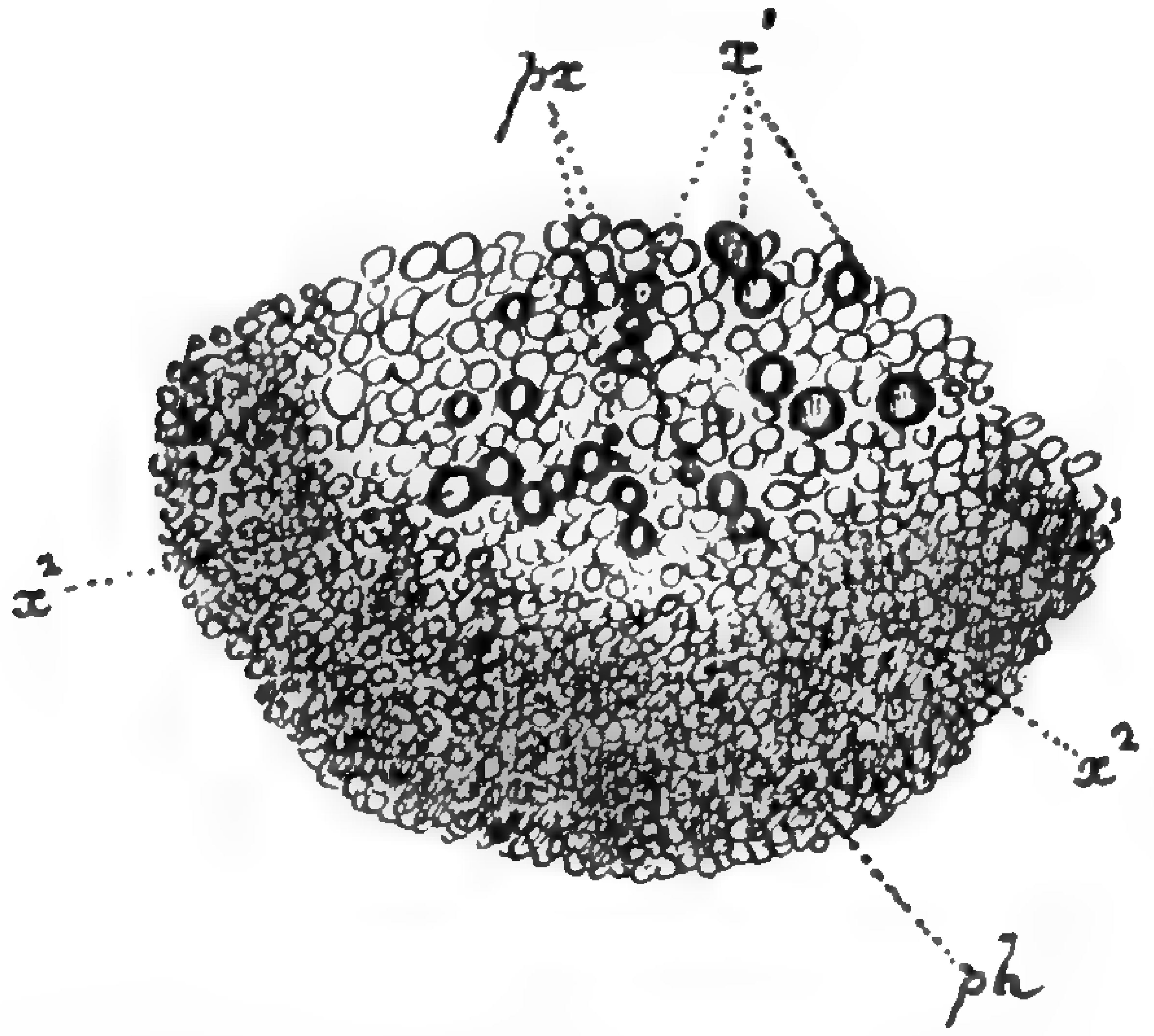
In all other Gymnosperms and in Angiosperms this tissue is, so far as hitherto observed, completely absent from the vascular bundles. No trace of any such tissue has been found either in the leaves of the Coniferæ or of the Gnetaceæ. In all these cases the whole of the wood has been regarded as centrifugally developed.

In investigating the structure of the *cotyledons* of some seedlings of *Gingko biloba*, grown in the Royal Gardens, Kew, I observed a most interesting point in regard to the minute structure of the vascular bundles, a pair of which traverse each cotyledon. In shape, as seen in transverse section, each bundle was curved, having the form of an arc of a circle. The phloem was very greatly developed. There was a cambium which, on the side of the xylem, had cut off but a very few elements; and to the inside of this lay the small group of protoxylem. On the ventral side of the protoxylem, however, and directly opposite the latter, there were yet other tracheides present, which, by their position and relative development, I determined to be none other than the equivalent of the centripetal xylem as it occurs

* The terms "centrifugal" and "centripetal," applied to the development of the parts of the bundle, are used with reference to the centre of the stem, in such a way that, in the case of the xylem, starting from the first-formed tracheæ (protoxylem), elements formed successively nearer the phloem (*i. e.* towards the outside of the stem) are called *centrifugal*, and those formed successively in the direction away from the phloem (*i. e.* towards the centre of the stem) are said to be *centripetally* developed. The same terms ("centrifugal" and "centripetal") are applied to the development of the bundles of the leaf whatever may be their orientation.

in the bundles of the leaves of Cycads. Moreover, these tracheides were very much scattered. In proportion as they receded further from the protoxylem towards either side of the bundle, they attained a greater diameter and, what more especially distinguished them, they were provided with reticulate thickenings on their broad transverse walls. In fact, they presented very much the appearance of the tracheides composing

Fig. 1.



Transverse section of vascular bundle from the upper part of the cotyledon of *Gingko biloba*. *ph*=phloem; *px*=protoxylem; x^1=centripetal xylem; x^2=transfusion-tissue.

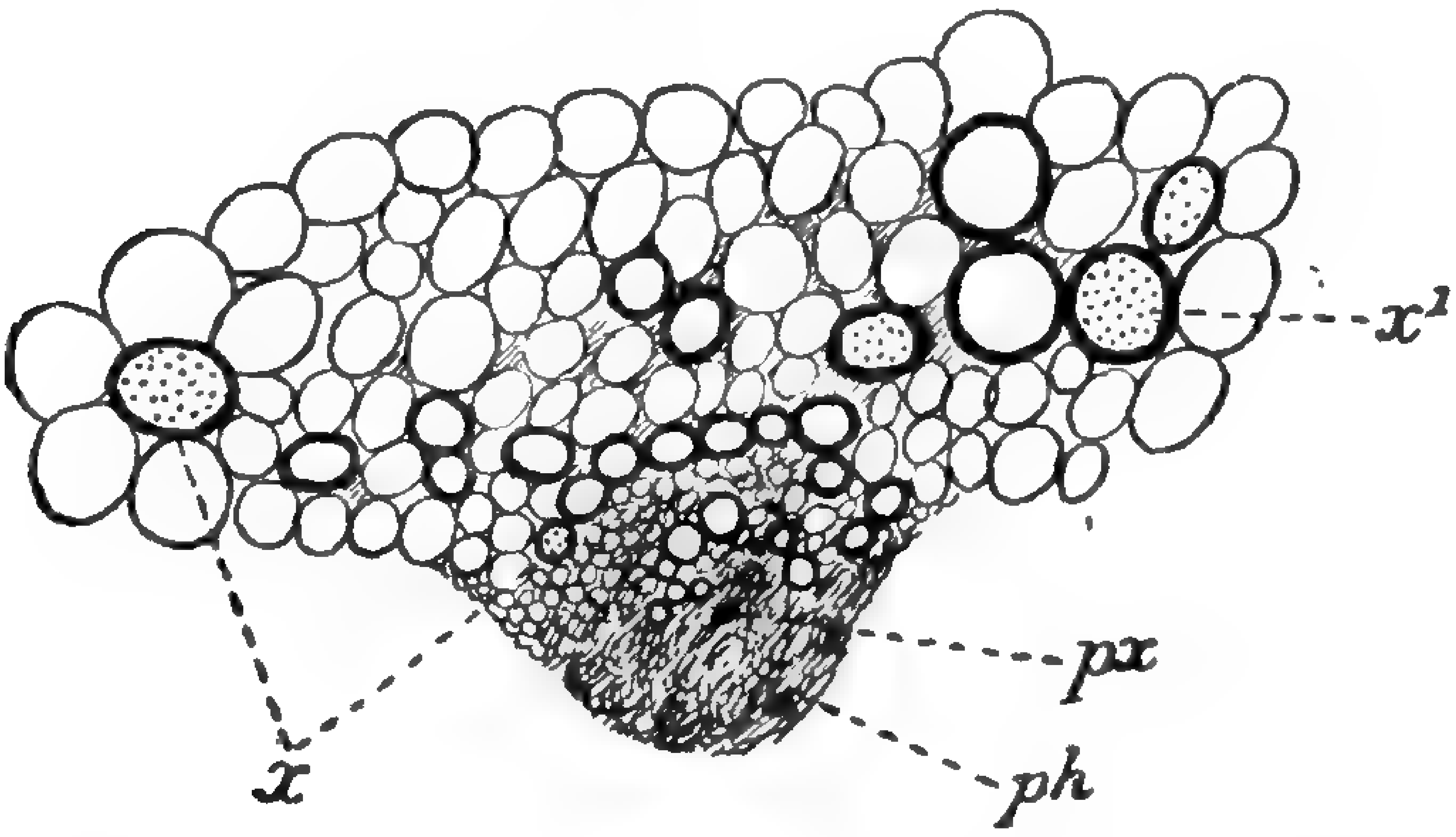
the transfusion-tissue in the leaves of Coniferæ. One or two of these tracheides which most completely resembled transfusion-tissue were situated quite on the side of the bundle and bordering on the phloem. In longitudinal section a most evident transition was seen between those tracheides nearest the protoxylem, which are elongated and narrow in shape, and those farthest removed from the latter, which are short and broad and in every way similar to the elements of the transfusion-tissue in Coniferous leaves.

In the bundles of the petiole of the foliage-leaf of *Gingko* there is a great development of the secondary centrifugal wood. But here also, on the inner or ventral side of the protoxylem, were seen two or three small tracheides of centripetal xylem. On the side of the bundle at the level of the phloem a few elements of typical transfusion-tissue were observed.

A study of the structure of the bundles in the cotyledons of *Cycas revoluta* revealed something very similar to the above. Here, as in *Gingko*, there was a relatively small development

of the centrifugal, but a great development, on the contrary, of the centripetal xylem. Here also could be distinctly seen a transition between the elements nearest the protoxylem, which were quite small, and other tracheides, of great diameter and with bordered pits on their *transverse walls*, which occurred scattered in the ground-tissue, often at a considerable distance from the bundle. It was interesting to see how some of these tracheides extended round towards the phloem.

Fig. 2.



Transverse section of vascular bundle from the upper part of the cotyledon of *Cycas revoluta.* *ph*=phloem; *px*=protoxylem; x^1=centripetal xylem.

In the leaves of some of those Coniferæ which approach nearest to *Gingko*, such as *Cephalotaxus* and *Taxus*, I observed tracheides on the ventral side of the protoxylem, which, by their position and general character, may be considered as equivalent to the centripetal xylem in *Gingko* and *Cycas*. After a rather extended investigation, I came upon similar instances in the leaves of *Dammara*, *Araucaria*, *Widdringtonia*, and *Pinus*.

Collating these facts with the structure as we have long known it of the vascular bundles of the leaves of Conifers and Cycads generally, it appears to me that there is a clue to be found as to the origin of the transfusion-tissue in these plants. This tissue, as seen in the cotyledonary bundles of *Cycas* and *Gingko*, is clearly an extension, towards the sides of the bundle, of the *centripetal xylem* of the latter. It is the successive, unlimited, centripetal development of the tracheides of this tissue which affords, as it were, the first start which has eventually culminated, in more modern plants, in the characteristic transfusion-tissue at the side of, or in various positions around, the vascular bundle. The transfusion-tissue, *e. g.*, of Coniferous leaves is not, as some have supposed, a distinctly new tissue

derived from the parenchyma of the ground-tissue of the leaf, or even of the pericyclic cells; nor is it, again, as others have imagined, the equivalent of a lateral vein or branch of the bundle. The conclusion at which I have arrived is that this tissue is a *direct derivative of the centripetal xylem* which normally occurred

Fig. 3.

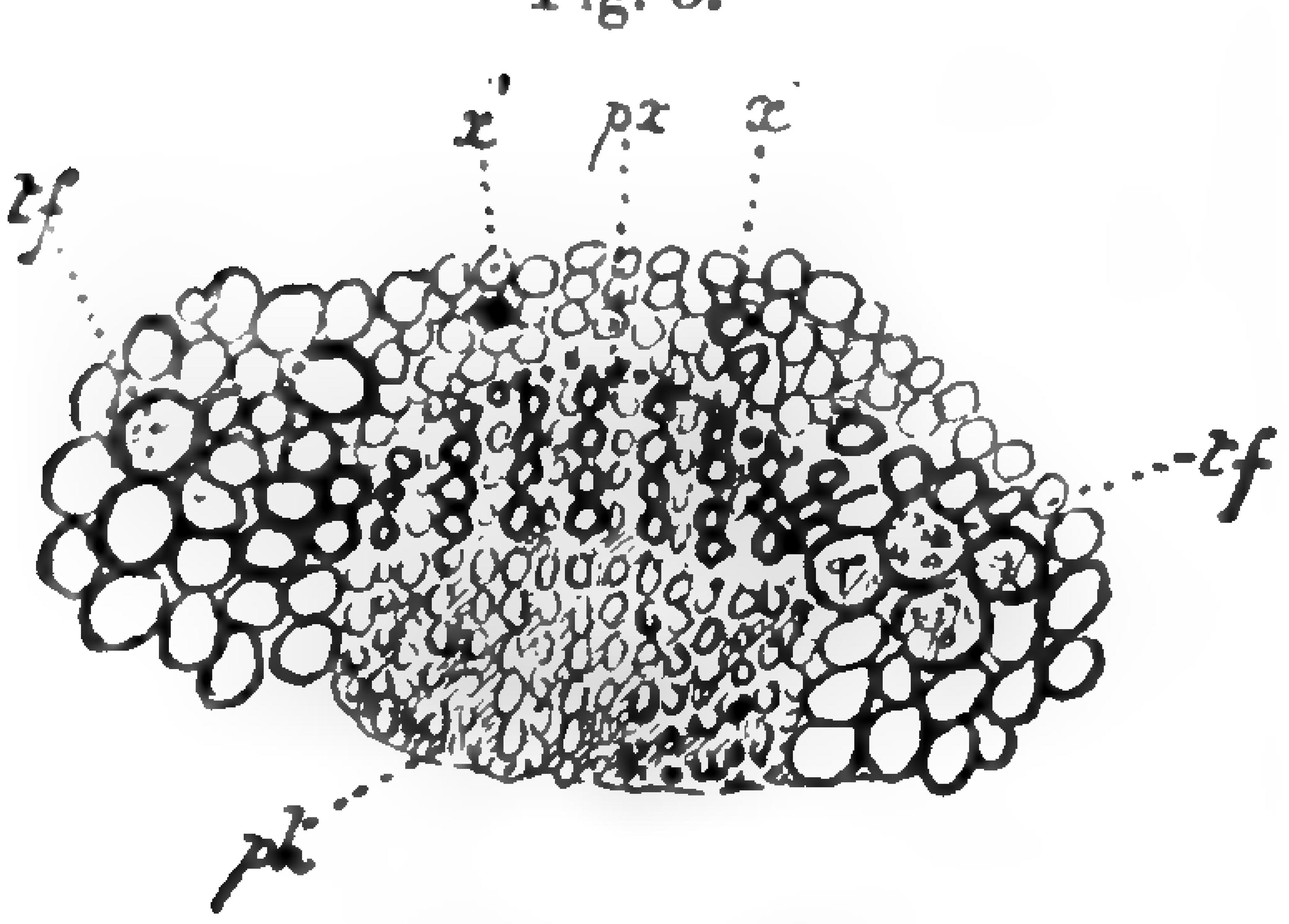


Fig. 4.

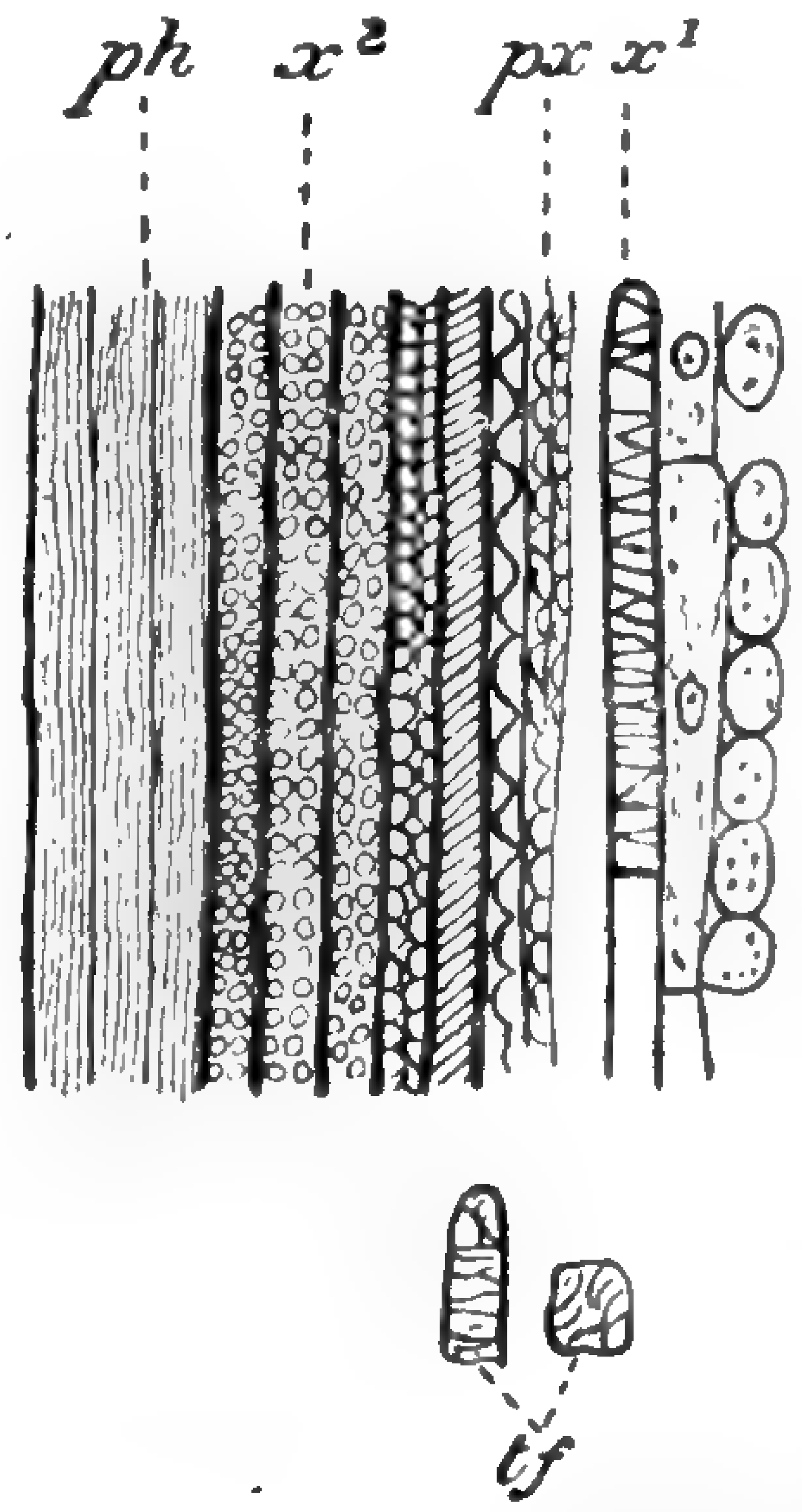


Fig. 3. Transverse section of vascular bundle of the leaf of *Taxus baccata*. *ph*=phloem; *px*=protoxylem; x^1=centripetal xylem; x^2=centrifugal xylem.

Fig. 4. Longitudinal section of vascular bundle from the leaf of *Dammara*, and two elements of transfusion-tissue. *ph*=phloem; *px*=protoxylem; x^1=centripetal xylem; x^2=centrifugal xylem; *tf*=transfusion-tissue.

as an important part of the vascular bundle in the ancestors of the plants concerned (for which fossil plants afford ample evidence). But as, in the course of time, the centripetal xylem of the bundle disappeared, as having become a useless tissue, the origin of the transfusion-tissue, which has persisted as a highly useful portion of the bundle, has become almost completely obscured.

[The figures illustrating this paper are drawn quite diagrammatically. At some future time I hope to publish a more detailed investigation of this subject, accompanied by fully-elaborated and accurate figures.

June 15, 1897. W. C. W.]

On the Evolution of Oxygen from Coloured Bacteria.

By ALFRED JAMES EWART, B.Sc., Ph.D., 1851 Exhibition Scholar, formerly Demonstrator of Botany in University College, Liverpool. (Communicated by Prof. J. REYNOLDS GREEN, D.Sc., F.R.S., F.L.S.)

[Read 15th April, 1897.]

THE relations of Bacteria to oxygen exhibit some of the most interesting and important phenomena of biological science, for in obligate anærobic Bacteria we are confronted with plants the respiration of which is apparently quite different from that of ordinary plants or animals. An explanation of the phenomenon of anærobism, which has been put forward by Pasteur, is that these organisms have the power of holding a supply of reserve oxygen. This hypothesis, however, fails to explain the existence of anærobic Bacteria, to which the presence of only a slight amount of oxygen is extremely injurious. In addition, Hesse * has shown that anærobic Bacteria in the absence of all free oxygen evolve CO_2 in such amount as can only be explained by supposing that the oxygen thus evolved is derived from the stable oxygen containing compounds in the nutrient medium.

Beyerinck †, arguing from the fact that phosphorescent Bacteria may continue to show phosphorescence for an hour or more after all oxygen has been absorbed by sodium hyposulphite, concludes that these organisms are exceptional in possessing a store of combined oxygen, present in sufficient amount to permit of respiration and phosphorescence continuing for a short time after all supply of external oxygen has been cut off. This does not, however, appear to be any reason for considering this phenomenon to be anything more than a manifestation of what is generally known as intramolecular respiration. Beyerinck also concludes that anærobic Bacteria require ultimately for the continuance of their life and vegetative activity a slight store of oxygen, and that this oxygen can be handed on from generation to generation. If held in such a manner its presence is impossible to detect, and, indeed, Beyerinck's statement amounts to little else but saying that combined oxygen is a constituent of

* R. Hesse, "Ueber die gasförmigen Stoffwechsel-Producte beim Wachsthum der Bakterien," in Zeitschr. f. Hygiene, Bd. xv. 1893, p. 17.

† M. W. Beyerinck, in Archives Néerlandaises, xxiii. pp. 416–427.

bacterial plasma. If, however, the oxygen were held in a loose and readily available form, occluded or in loose chemical combination, it should be possible to detect the presence of such oxygen by chemical, physical, or biological methods.

The fact that certain coloured Bacteria can, when exposed to light, evolve traces of oxygen has now for some time been known. Engelmann * has described a motile green bacterium, which possesses a faint power of assimilation, and also states that the same power may be shown by the "Purpur-Bakterien," in which not chlorophyll but a different pigment, "Bakteriopurpurin," having a totally different absorption spectrum to that of chlorophyll, is present. The main absorption of bacteriopurpurin takes place in the ultra-red; and Engelmann has succeeded in establishing the fact that the red Bacteria are capable of relatively fairly active assimilation when exposed to the invisible ultra-red heat-rays.

Since Engelmann no other author has published anything bearing directly on this question, though such epoch-making researches are naturally always in need of confirmation and corroboration. Many other Bacteria also are coloured or have the power of forming pigments; but the question as to what the utility of these pigments may be has never been answered satisfactorily, and has only in a very few cases even been attempted.

Thus Beyerinck † considers that in what he terms parachromophoric Bacteria the pigment is to be regarded as an excrete waste or by-product of destructive metabolism. The same is probably the case with the chromoparic Bacteria (*Bacillus cyaneo-fuscus*, *B. cyanogenus*, *B. pyocyaneus*, *B. virescens*, *B. prodigiosus*). On the other hand, in chromophoric Bacteria, in which Beyerinck includes the green, red, yellow, and brown Bacteria, which do not fluidify gelatine, the pigment, since it forms an integral part of the bacterial plasma so long as this is living, must have an important biological meaning. One possibility is that the pigments in these cases are assimilatory pigments like chlorophyll, etiolin, and bacterio-purpurin. It was with the intention of determining this point, and also of

* T. W. Engelmann, in Bot. Zeit. 1882 and Oct. 1888.

† M. W. Beyerinck, in Bot. Zeit. 1891: "Die Lebensgeschichte einer Pigment-Bakterie."

testing the observations made by Engelmann upon green and purple Bacteria, that the following investigation was undertaken, the results of which seem to make clear the function of the pigment in certain of the Bacteria examined.

If a quantity of a certain brown bacterium, *Bacillus brunneus*, is enclosed along with *Bacterium Termo* in a cover-glass preparation and ringed with vaseline, it is at once seen that the *B. Termo* remain in active movement for a considerable time in the neighbourhood of the masses of *Bacillus brunneus.* The most convenient method of demonstrating this phenomenon is by mixing a small quantity of *B. brunneus*, taken from an agar culture by means of a sterilized platinum spatula, with a small drop of cool but still fluid gelatine on a slide. When solidified, a drop of water containing active *Bacterium Termo* is added, and the whole is at once covered, all air-bubbles being excluded and ringed as usual. Round the edges of the gelatine, and especially in any bays or indentations which may be present, the *B. Termo* continue in at first very active movement, which gradually becomes weaker and finally, after several hours, ceases. If the gelatine is made in ring form, the *B. Termo* move with about equal rapidity on the inner and outer sides of the ring. There is hence no error due to any diffusion of oxygen from outside through the ringing of vaseline.

A possibility of error is that the gelatine in such preparations may be an exciting or aiding cause for the movement of *B. Termo*, for a short time at least. In preparations made, however, with *B. Termo* and gelatine alone, all movement ceases in a few (5–10) minutes. A second possibility is that the movement may be caused by some unknown excrete bacterial product, and not be due to oxygen. If preparations are made with a drop of the filtered exuded fluid from an agar culture of *Bacillus brunneus*, or with Bacteria which have been heated to 100° C. for a few minutes, in a few minutes the *Bacterium Termo* is entirely at rest. Fresh gelatine preparations, which have been soaked in water for 15 to 30 minutes, show, on adding *B. Termo* and closing, a quite active movement as usual.

An additional indication that the exciting cause of the movement is oxygen is afforded by the fact, that if *Spirilla* are introduced these collect at a distance from the edge of the gelatine, after several hours coming nearer and nearer and finally touching it. The evolution of oxygen is therefore at first suffi-

ciently strong to repel *Spirillum*, in accordance with the general rule that an oxygen partial pressure, which suffices to keep *Bacterium Termo* in active movement, will repel *Spirillum*.

It was also found that this phenomenon was by no means restricted to *Bacillus brunneus*, but is also shown by a number of other coloured Bacteria. Thus in *Bacillus cinnabareus*, Flügge (vermilion); *Bacillus janthinus*, Zopf (indigo-blue); *Staphylococcus citreus*, List (yellow); *Micrococcus agilis*, Ali Cohen (coral-red); and *Sarcina aurantiaca*, Flügge (brownish-yellow), the evolution of oxygen is as active, or nearly as active, as in *Bacillus brunneus*, Adametz; but in *Sarcina rosea*, Flügge (pink), and *Diplococcus roseus*, Flügge (rose-pink), is weaker, and in *Sarcina lutea*, Flügge (yellow), is much weaker *.

Definite proof that the exciting cause of the movement of *Bacterium Termo* is really oxygen was obtained in the following manner:—A small portion, about the size of a lentil or split pea, of the coloured bacterium to be examined is enclosed in a small gas-chamber, at first Ranvier-Prazmoski's being used, but later solely a special chamber devised by Prof. Pfeffer. On the upper surface a cover-glass, having on its under surface a hanging-drop of *B. Termo*, is fixed and sealed with vaseline-wax. A current of pure H † is then led through until the *B. Termo* come to rest, when the tubes leading to and fro from the gas-chamber are closed by clamps. In from one to several minutes the *B. Termo* recommence to move and are soon in active movement. This stoppage and recommencement can be repeated time after time. It follows, therefore, that the coloured Bacteria examined have the property of evolving a gaseous substance which causes *B. Termo* to move actively, the gas necessarily being oxygen. An additional proof that the gas evolved is oxygen is afforded by the fact that it is capable of causing reduced indigo-carmine to turn blue again. This is demonstrated as follows:—A current of hydrogen is passed through 3 flasks kept submersed under water. The 1st and 3rd of these contain a solution of reduced indigo-carmine to which a little

* All of these Bacteria grow best on peptone agar, with or without sugar, and at 20° C. to 25° C.

† In addition to the usual purifying-tubes, the H is passed over pyrogallol and KHO. The surface of the acids in the Kipp's generating apparatus is covered with paraffin liquidum, whilst the purifying-tubes and all india-rubber connexions are kept immersed under water.

zinc dust is added, so that any blue tinge acquired whilst the air is being driven out can be removed by shaking. After a certain time the tubes between the flasks are clamped, and after a few hours the current is renewed, when the gas in the 2nd flask, which contains a bouillon culture of *Bacillus brunneus*, is slowly driven through the 3rd flask. The reduced indigo-carmine in the latter acquires in the upper layers a distinct blue tinge, showing that oxygen has been evolved from the culture of *B. brunneus*. The time necessary to drive out all oxygen from the flasks is determined by previous experiments made with sterile bouillon. On reclamping and leaving for a few hours, no further evolution of oxygen can be detected from the *B. brunneus* culture.

That the oxygen is evolved in the normal form as O_2, and not as ozone or O_3, can be shown by testing with a hanging-drop of KI and starch in an atmosphere of hydrogen.

The following experiment seems to show that the evolution of oxygen is a vital process continuing only as long as the Bacteria remain living. The usual chamber arrangement having been set up and a quantity of *B. brunneus* enclosed, a drop of concentrated $HgCl_2$, previously contained in a bulb in the tube leading to the chamber, is driven by the current of hydrogen, on inclining the tube, into the chamber and comes into contact with the *B. brunneus* lying on the floor of the latter, and separated from the outer half by a streak of vaseline. The evolution of oxygen from the bacterial mass is at first quickened, but then rapidly weakens and ceases entirely in about an hour or so. The process therefore appears to be a vital one, ceasing as soon as the $HgCl_2$ reaches the centre of the bacterial mass and the Bacteria are killed. As will be shown later, however, this phenomenon has really a quite different bearing on the problem at issue.

At first sight it appears as if we had here to do with an assimilatory process, the oxygen evolved being derived from the assimilation of CO_2 and the bacterial pigment being an assimilatory pigment. Were this so, it would be natural to expect the evolution of oxygen to take place more actively in an atmosphere of H + a little CO_2, than in an atmosphere of H alone. That oxygen can be evolved in an atmosphere of H is no proof that it is not derived from a process of assimilation, for green algæ exposed to light in an atmosphere of H evolve sufficient oxygen to keep *Bacterium Termo* in a hanging drop in active

movement, even though a small drop containing only a hundred or two of *Bacterium Termo* is used, from which no appreciable trace of CO_2 is evolved.

It appeared at first as if the coloured Bacteria evolved oxygen more rapidly in an atmosphere of H containing a little CO_2 than in an atmosphere of pure H. The experiments were performed in the following manner:—The time which it takes for the *B. Termo* which have been brought to rest by a current of H to recommence to move, when the tubes leading to and from the chamber containing the coloured Bacteria are clamped, is determined. Then a mixture of H and CO_2 is passed through the chamber, when, on closing, the *B. Termo* recommence to move in a shorter time than they did alone. Further examination showed, however, that this difference was due to the presence of traces of oxygen in the CO_2 employed. To remove this oxygen the CO_2 was passed over tubes of pyrogallol and KHO. Theoretically, owing to the absorption of the CO_2 by the potash, this arrangement should be unworkable, but practically it was found possible to obtain CO_2 in this manner perfectly free from all traces of oxygen. The evolution of oxygen can now be demonstrated to take place with equal rapidity in an atmosphere of H alone, as in one composed of H with a little CO_2.

A possibility not as yet excluded is, however, that a process of assimilation might be carried on at the expense of the CO_2, provided by the respiration of the Bacteria themselves or by the decomposition of organic acids or other organic substances. That oxygen can be evolved by chlorophyllaceous assimilation without any external CO_2 being present has been shown to be the case by Meyer * and others in all fleshy plants.

By means of the gas-chamber and hanging-drops of *B. Termo* and of a very weak alkaline solution (0·5 % Na_2CO_3) of phenolphthalein, it can readily be demonstrated that green algæ, leaves of mosses, &c., exposed to optimal illumination in an atmosphere of H, evolve both traces of oxygen and traces of CO_2 simultaneously. The same is the case with the coloured Bacteria, but here the evolution of oxygen and more especially the evolution of CO_2 are with fresh preparations under such conditions much stronger. Thus the green algæ exposed to light in H evolve sufficient CO_2 to decolorize a drop of phenolphthalein

* A. Meyer, Landwirthschaftliche Versuchs-Stationen, xxi. p. 227 *et seq.*; E. L. M. Aubert, in Rev. gén. de Bot. 1892, pp. 421 & 558.

in $1\frac{1}{2}$ to 2 hours, whereas with an equal bulk of the coloured Bacteria this takes place in $\frac{1}{4}$ hour. The green algæ exposed to light in an atmosphere of H also cause the Bacteria in a hanging-drop of *Bacterium Termo* to move rather actively in 3–5 minutes; but if the H used contains a little CO_2, or if an equal bulk of coloured Bacteria is used, the *B. Termo* commence to move a minute or two sooner.

The evolution of CO_2 in an atmosphere of H by the coloured Bacteria can also be demonstrated by the precipitation of $BaCO_3$ in a hanging-drop of BaH_2O_2, and by the partial or complete re-dissolving of freshly precipitated $CaHPO_4$. After being in the chamber in an atmosphere of H for as long as 24 hours, a mass of *Bacillus brunneus* may still be able to evolve traces of CO_2, though all evolution of oxygen has long since ceased and no external supply is present.

In gelatine preparations or in the chamber in H, the evolution of oxygen does not continue for an indefinite length of time, but sooner or later ceases. Where the evolution of oxygen is weak it generally ceases in 2–3 hours (*Sarcina lutea*, *Diplococcus roseus*, &c.), but where it is stronger (*Bacillus brunneus*, &c.) it generally continues for 5–6 hours, and in some cases a faint evolution of oxygen may still be shown after 10–12 hours.

This gradual diminution and final cessation of the evolution of oxygen might be due to the Bacteria being gradually more and more injuriously affected. A mass of Bacteria, however, which has ceased to evolve oxygen in the gas-chamber in hydrogen, after being re-exposed to air for some time, may again show a distinct evolution of oxygen, though weaker and of shorter duration. It is possible that this phenomenon might be due to the induction of a condition of assimilatory inhibition from which on re-exposure to air recovery takes place, and which corresponds to the condition of inanition which is finally induced in *Chara* when kept in an atmosphere of H, and from which on exposure to air a more or less rapid recovery may take place.

The fact that these coloured Bacteria grow and develop quite normally on agar or gelatine cultures and form their pigment in the darkness, is no argument against their possessing an assimilatory pigment and being also able to assimilate as green plants do; for many plants can form chlorophyll in the darkness, and all can form etiolin, whilst Beyerinck has shown that it is possible to

isolate and develop certain minute green Algæ (*Chlorella vulgaris*, Beyerinck, &c.) on gelatine.

Were, however, the oxygen evolved by the coloured Bacteria a product of an assimilatory process, it would be natural to expect that they might be cultivated upon inorganic media or on media containing nitrogen and carbon in the form of simple organic compounds. The whole of the 9 Bacteria mentioned as showing a power of evolving oxygen were inoculated in the following solutions:—Sol^n A (K_3PO_4 2 grms.; Am_2SO_4 5 grms.; $MgSO_4$ 0·14 grm.; 4000 c.c. H_2O). Sol^n A+(1) $NaHCO_3$; (2) $CaCO_3CO_2$; (3) 3 p. c. grape-sugar; (4) 4 p. c. cane-sugar; (5) 2 p. c. glycerine; (6) 1 p. c. asparagin; (7) 1 p. c. asparagin +2 p. c. glycerine; (8) 1 p. c. asparagin+3 p. c. grape-sugar; (9) 1 p. c. asparagin+3 p c. grape-sugar+2 p. c. glycerine.

In none of these solutions in either light or darkness can the coloured Bacteria develop. In 7, 8, and 9 a slight trace of almost colourless sediment may be found, but in all the others not the least growth takes place. These Bacteria all develop normally and abundantly only on nutrient media containing peptone. On peptone-agar and peptone-gelatine they develop well and form abundance of pigment without any sugar being necessary, but in bouillon cultures the presence of sugar slightly favours their growth and pigment formation. They are all pronounced obligate saprophytes.

Other results also tend to show that the oxygen evolved is not the product of a process of assimilation. Thus the evolution of oxygen apparently continues as actively and persists for as long a time in the darkness as in the light. This might, however, really be due to the evolution of oxygen recommencing instantaneously on re-exposure to light. For comparative purposes, gelatine preparations of *Protococcus*, *Scenedesmus*, &c. were made and examined. These show at the edge of the gelatine an active evolution of oxygen. In darkness, in under 5 minutes the *Bacterium Termo* come completely to rest, and on re-exposure to light recommence to move in 15–30 seconds (according to the thickness of the rim of gelatine between the outermost algal cells and the surrounding *B. Termo*), and are in fully active movement in 1–2 minutes. With gelatine preparations of *Bacillus brunneus* the evolution of oxygen is on re-exposure to light seen to be normally active however instantaneous the examination may be, and

indeed it persists slightly longer in darkness than it does in light.

Thus preparations exposed to sunlight, but kept cool by being floated on water, cease in 1–2 hours to evolve oxygen; whereas similar preparations after being exposed to diffuse daylight for 8 hours showed a weak evolution of oxygen, which in preparations kept in the darkness for the same time was still moderately active.

If the dark heat-rays from a large flask filled with hot water are collected and thrown upon gelatine preparations, when the evolution of oxygen is already fairly active, no further increase can be detected. When, however, the evolution of oxygen is very faint or has almost ceased, a distinct increase or recommencement of the evolution of oxygen lasting for a short time may be shown.

The further study of the influence of external radiation upon the evolution of oxygen was carried out by the gas-chamber and hanging-drop method. The microscope was isolated upon a clay dish, through which the tubes passed, and was covered by cylinders of metal, cardboard, clay, &c. After hydrogen has been passed through the time that elapses, when the preparations are exposed to light, before the *Bacterium Termo* in the hanging-drop recommence to move is noted and the time when they are in active motion. A cover is now placed over the microscope and a current of H is passed through for the time necessary to bring the *B. Termo* again completely to rest, when the tubes are clamped and the time noted. After a time the cover is removed and the hanging-drop at once examined. In this way the times necessary for *B. Termo* to recommence to move under the given conditions is found, and this represents the relative rates at which oxygen is evolved under these conditions. By this means it was definitely established that the evolution of oxygen was independent of all external radiation, that it is slightly accelerated by the dark heat-rays, but when so accelerated ceases correspondingly sooner.

If the coloured Bacteria are heated to 100° C. and then mounted, no evolution of O is shown. Preparations kept at 30° C. in light or in darkness show at first a very active evolution of oxygen, which in 2–4 hours, however, entirely ceases; whereas similar preparations kept at 20° C. in darkness or exposed to diffuse light still show a weak but distinct evolution of oxygen. At

4° C. a fairly active evolution of oxygen is shown, which after 5 hours is still present but weak. Preparations kept at 4° C. which have just ceased to evolve oxygen may, on being brought to 20° C. in light or in darkness, or on a hot water-bottle being placed before the mirror, again show a weak evolution of oxygen continuing for a short time. At 4° C. the dark radiant heat-rays exercise a distinct accelerating effect upon the evolution of oxygen, causing it to be for a time more active but also to be of shorter duration.

Altogether the foregoing results form a conclusive proof that the oxygen evolved is not the product of any assimilatory process involving an absorption of radiant kinetic energy and the conversion of this into potential chemical energy. Two other explanations of the phenomenon alone remain, namely, that either the oxygen evolved is a by-product of some unknown katabolic process induced by the bacterium in the nourishing medium or taking place in its own plasma; or that the oxygen is simply absorbed oxygen taken from the air and held in a state of loose combination and at a lower partial pressure than that of the atmosphere being slowly given off again.

The fact that at 4° C. the evolution of oxygen continues fairly actively, although at this temperature none of the coloured Bacteria mentioned can grow or multiply, and the fact that the Bacteria taken from agar-cultures 2–3 months old, in which by far the greater number of the Bacteria must be dead, may show a quite active evolution of oxygen on examination, form almost conclusive objections to the first hypothesis. Conclusive proof that the phenomenon is not connected with the vitality of the bacterium itself is given by the fact that old cultures, or cultures kept for many hours over ether-vapour, or cultures heated to 80° C. for an hour, from which on re-inoculation no new growth takes place may show on examination an active evolution of oxygen, though frequently weaker than normal *. Thus agar-cultures of *Bacillus brunneus, Micrococcus agilis, Sarcina aurantiaca*, killed by heating to 80° C. for $1\frac{1}{2}$ hours, showed after 2

* If the Bacteria are heated to 60° C. or 70° C. or exposed to ether-vapour for a time, but not long enough to kill them entirely, or inoculating in fresh agar-tubes, a slight and very slow growth may take place and the pigment is formed as usual, though not abundantly. The colonies, however, soon cease to grow, and now, as a general rule, on re-inoculating in fresh tubes no new growth takes place. The vegetative vigour has been so weakened that the power of growth is finally completely lost.

weeks an active evolution of oxygen; in *Sarcina aurantiaca* and *Micrococcus agilis* becoming weak in 2–3 hours and ceasing in 3–4 hours; in *Bacillus brunneus* becoming weak in 5–6 hours and ceasing in 8–10 hours. The colour of the cultures of *B. brunneus* is slightly faded on the outer surface only, in the other two is unaltered. Similarly after 3 weeks a fairly active evolution of oxygen is still shown on examination.

The power of evolving oxygen is in very close connexion with the presence of the pigment. Thus in young growths the pigment is at first almost or entirely absent. Such show no power of evolving oxygen. Also if inoculated on slightly acid bouillon, or if after inoculation the cultures are kept for a day or two at 35° C. to 40° C. and then brought to 20° C., the subsequent growth may remain for a long time, or permanently, entirely or almost entirely colourless. Such colourless cultures on examination, either by the Bacterium method or by the analytical method described later, show no evolution of oxygen. Cultures in which a small amount of pigment is present show a correspondingly weak power of evolving oxygen.

The nature and properties of the pigment-substance, though its colour varies in the different Bacteria from red to indigo-blue, is in all cases essentially the same. Their insolubility in water, and solubility in ether, alcohol, benzol, and chloroform, and the changes of coloration displayed on treatment with sulphuric and nitric acids, show them to belong to the class of pigments known as Lipochromes. Thus in all cases with concentrated H_2SO_4 the pigment turns bluish green, whilst with NaHO the original colour returns. With HNO_3 a bluish-green tinge is first produced, but this is almost at once further oxidized and passes through a series of colours until finally it becomes almost or quite colourless.

In all the above 9 Bacteria, as soon as the culture becomes deeply coloured, the main mass of the pigment is external to the Bacteria. Owing to its fatty nature, however, the pigment does not diffuse, but remains in close association with and as an integral part of the culture from which it was developed. In *Staphylococcus citreus*, *Sarcina aurantiaca*, and *Bacillus brunneus*, when the isolated Bacteria are examined with high powers ($\frac{1}{16}$ immersion) a very faint tinge of coloration may in many cases be detected, but the other 6 Bacteria appear to be perfectly colourless. If the cultures have been heated to 80° C. or over ether-vapour for

some time, all of the colour-forming Bacteria may often show a distinct trace of coloration. Hence probably in all cases the living bacterium is colourless. If the pigment is excreted as such, at any given moment the Bacteria should contain a slight amount, though this might be insufficient to give them a perceptible coloration when examined singly. On the other hand, it is quite possible that the pigment is excreted as a colourless chromogen, later altering perhaps by a process of oxidation and becoming coloured. If oxygen is deficient or absent, the pigment is not formed, and in the stab-canal of an agar-culture the pigment develops more slowly than on the surface.

It is worthy of note that no perceptible change of coloration takes place in preparations which have evolved all the oxygen they are capable of giving off. Schneider, however, finds that deoxidizing agents, such as zinc dust+acetic acid, decolorize the pigment from *Bacillus janthinus* and *Sarcina aurantiaca*, partly decolorize that from *S. rosea*, and do not at all affect that from *Micrococcus agilis* and *Sarcina lutea*. Strong oxidizing agents on the other hand, such as HNO_3, in all the 9 colour-forming Bacteria rapidly decolorize the pigment.

From the above it is clear that the phenomenon is not a vital but a physical one, the excreted pigment having the power of absorbing oxygen from the air, and then, when the partial pressure is lowered, slowly evolving it again. Hence a preparation in hydrogen in the gas-chamber which has ceased to evolve oxygen, after being re-exposed to the air for some time, may again show a distinct evolution of oxygen; whereas, however long it may remain in hydrogen in the closed chamber, once the evolution of oxygen has completely ceased, it never recommences.

The further study of the problem was continued by analytical methods, using the improved form of Bonnier and Maugin's apparatus for the estimation of CO_2 and O described by Aubert*. Cultures of the Bacteria grown on bouillon are introduced into small bulbs with a bent neck, in which a little air is left. The open ends of the tubes are immersed in Hg covered by a film of water, and after a given length of time the gas is collected over Hg and examined.

The following are some of the results thus obtained with 7 to 14 days old cultures of *Bacillus brunneus*, at 20° C.:—

* Aubert, in Rev. gén. de Bot., Mars 1891.

Amount of Culture.	Amount of Air enclosed.	Time.	Oxygen present.	CO_2 present.
5 c.c.	3 c.c.	16 hrs.	19·3 p. c.	0·41 p. c.
5 c.c.	3 c.c.	16 ,,	19·8 p. c.	0·3 p. c.
5 c.c.	3 c.c.	16 ,,	20·3 p. c.	0·2 p. c.
100 c.c.	20 c.c.	8 ,,	17·09 p. c.	1·81 p. c.
20 c.c.	10 c.c.	20 ,,	11·7 p. c.	3·55 p. c.
25 c.c.	10 c.c.	28 ,,	9·8 p. c.	2·5 p. c.
*50 c.c.	10 c.c.	26 ,,	0·17 p. c.	7·2 p. c.
†1·2 grm.	9 c.c.	24 ,,	13·4 p. c.	2·99 p. c.

* Contains an exceptionally large amount of Bacteria.
† From agar-cultures weighed moist.

The above results show that, confined in a limited supply of air, no evolution of oxygen is shown, but the percentage of oxygen present steadily diminishes and finally reaches almost *nil*, whilst at the same time a certain amount of CO_2 is produced corresponding to about one-third of the oxygen which has disappeared. This peculiarity in the respiration of Bacteria has already been pointed out by Hesse. For the solution of our problem this says nothing, the oxygen which disappears being in all probability built up into the substance of the developing Bacteria.

Instead of the above arrangement, the following was adopted:—The lower halves of test-tubes drawn out so as to be narrowed in the middle are partly filled with a mass of the coloured Bacteria taken from bouillon or agar cultures along with a little fluid. By means of a thick capillary tube a current of H is passed through the test-tube, the mouth of which is closed by an india-rubber cork, through which a finely pointed exit-tube passes, until all air has been driven out, when the narrow part is heated and the tube drawn out and sealed whilst the stream of hydrogen is still passing through. The living Bacteria may be examined in this manner or they may be killed by $HgCl_2$, either added before sealing or after, by enclosing a tube filled with $HgCl_2$ solution, which after closing is inverted and the contents of the inner and outer tubes allowed to mix. After a given time, the sealed tube is opened under Hg and the contents collected and examined.

Test experiments were performed with tubes containing sterilized meat-extract. In such cases, after passing a current of

hydrogen through for 10–15 minutes, no perceptible oxygen can be detected in the hydrogen enclosed when analysed.

With *Bacillus brunneus* the following results were obtained (temp.=20° C.) :—

Amount of Fluid.	Of H.	Of Bacteria *.	Time.	Condition.	O.	CO_2.	O evolved per grm. moist weight of Bacteria.
					p. c.	p..	
18 c.c.	3 c.c.	2 grms.	5 hrs.	$HgCl_2$ after sealing.	21·1	0·59	0·316 c.c.
18 c.c.	3 c.c.	2 ,,	5 ,,	Living and normal.	17·8	0·42	0·267 c.c.
18 c.c.	3 c.c.	2 ,,	5 ,,	$HgCl_2$ before sealing.	20·3	0·51	0·309 c.c.
18 c.c.	3 c.c.	2 ,,	6 ,,	$HgCl_2$ after sealing.	30·0	0·66	0·45 c.c.
20 c.c.	3 c.c.	1 grm.	26 ,,	Living and normal.	0·0	1·72†	0·0 c.c.
20 c.c.	3 c.c.	1 ,,	16 ,,	8 hrs. $HgCl_2$, then H and sealed.	0·2	Trace.	0·006 c.c.
18 c.c.	5 c.c.	0·5 ,,	10 ,,	6 hrs. $HgCl_2$, then H and sealed.	0·18	0·38	0·018 c.c.

* The Bacteria if obtained from agar-plate cultures are weighed direct moist; if from bouillon, the superfluous fluid is drained off and the mass after drying with filter-paper weighed.

† The amount of CO_2 is disproportionately small, owing to a large part remaining dissolved in the enclosed fluid.

From the above it appears that *B. brunneus* can evolve per gramme of dry weight from 0·2 to 0·45 c.c. of oxygen, which is a quite appreciable amount. Later results gave, however, a lower value. If the Bacteria remain living, this evolved oxygen is all used up again. If $HgCl_2$ is added, the pigment is so altered that it loses its power of occluding oxygen, and the same also takes place when heated to 90° C.–100° C. for some time, and that more rapidly if heated in a bouillon-culture than in pure water.

The following experiment shows that the oxygen formed is actually derived from the bacterial culture, and is not due to any error in the method employed:—Through a tube containing 1 gramme of Bacteria to 18 c.c. of fluid and 3 c.c. of gas, H is passed for 5 minutes, and then a sample of the gas issuing through the distal tube is collected over Hg and analysed. It contained 0·6 per cent. CO_2 and 0·5 per cent. oxygen; a second sample,

collected after 15 minutes, contained 0·2 per cent. CO_2 and 0·0 per cent. oxygen; a third sample, collected after 25 minutes, contained no appreciable trace of either O or CO_2. The tube was then at once sealed and, by inverting, the contents were mixed with $HgCl_2$. Examined after 8 hours, the enclosed H contained 0·5 per cent. CO_2 and 2·8 per cent. oxygen (per gramme of bacteria = 0·2 c.c. oxygen). A prolonged current of H therefore apparently gradually drives out the oxygen held in a state of loose combination by the bacterial pigment. The loss of oxygen is still more rapid if $HgCl_2$ has been previously added. Thus a tube of *Bacillus brunneus* to which $HgCl_2$ had been added before H was passed through evolved per gramme of bacteria (bouillon-culture) 0·057 c.c. oxygen; whereas if H was passed through a similar tube of normal material, and then, after sealing, this at once heated to 90° C., per gramme 0·11 c.c. of oxygen was evolved.

This method cannot be claimed to give really accurate quantitative results, though from a qualitative point of view it is perfectly satisfactory. One serious error is due to the fact that any liquid enclosed has the power of holding in solution a certain amount of the oxygen present. This error is obviated by using relatively large amounts of hydrogen and reducing the amount of fluid enclosed to a minimum. Also, before sealing, the flame is allowed to play upon the upper part of the tube before the narrowing, and then the tube at once drawn out. On cooling a partial vacuum is produced in the sealed portion of the tube. This is at once placed in water at 90° C. to 100° C., when the Bacteria are killed and at once cease to respire, and the presence of a partial vacuum prevents the tube from bursting. Minute bubbles of gas can generally be seen to be evolved from the bacterial mass when thus heated. After the lapse of an hour or two the tube is taken out, allowed to cool, and the tip is broken off under Hg; when the Hg as a general rule runs in so far as to show that a distinct negative pressure varying from $\frac{1}{3}$ to $\frac{1}{2}$ of an atmosphere was still present in the tube. The gas is then collected and analysed. From the percentage of oxygen present in the measured amount of H enclosed, the actual amount of oxygen evolved can be calculated. In this way, using a moist weight of Bacteria varying from 0·2 grm. to 1 grm., the following calculations were made:—

Name.	Moist Weight.	Grown on :	Pigment.	O evolved per grm. Bacteria (moist weight).
Micrococcus agilis ...	0·6 grm.	Faintly acid Bouillon.	Only in small amount.	0·023 c.c.
" " ...	0·5 "	Bouillon at first at 35° C.	Colourless.	0·0 c.c.
" " ...	0·25 "	Agar.	Abundant.	0·137 c.c.
Sarcina rosea.........	0·65 "	Faintly acid Bouillon.	But little.	0·021 c.c.
" "	0·6 "	Neutral Bouillon.	Mod. abundant.	0·086 c.c.
" "	0·25 "	Agar.	Normal.	0·13 c.c.
Sarcina lutea.........	0·5 "	Slightly acid Bouillon.	Colourless.	0·0 c.c.
" "	0·5 "	Neutral Bouillon.	Mod. abundant.	0·051 c.c.
" "	0·5 "	Agar.	Normal.	0·066 c.c.
Sarcina aurantiaca .	0·35 "	Bouillon.	Mod. abundant.	0·11 c.c.
" " .	0·5 "	Agar.	Normal.	0·14 c.c.
Bacillus cinnabareus.	0·3 "	Bouillon.	Fairly abundant.	0·11 c.c.
" "	0·3 "	"	"	0·104 c.c.
" "	0·43 "	Agar.	Normal.	0·144 c.c.
Staphylococcus citreus	0·45 "	"	"	0·118 c.c.
Diplococcus roseus ...	0·3 "	"	"	0·128 c.c.
Bacillus brunneus ...	0·4 "	Starch-paste.	"	0·13 c.c.
" " ...	0·5 "	"	"	0·127 c.c.
" " ...	0·6 "	Agar.	"	0·16 c.c.
" " ...	0·8 "	"	"	0·18 c.c.

Where the pigment is poorly developed the power of evolving oxygen is also slight. Cultures of *Bacillus brunneus* on potatoes and starch-paste appear to be as deeply coloured as when grown on agar, but show a weaker evolution of oxygen in the former case than in the latter.

Cultures killed by treatment with ether or by heating to 80° C. for an hour, may still possess a considerable power of absorbing and then evolving oxygen. Thus the Bacteria from a bouillon-culture of *B. brunneus*, after being heated to 80° C. for one hour and then exposed to air for a day, could evolve per gramme of Bacteria 0·13 c.c. of oxygen in one case and 0·12 c.c. in another. If, however, the cultures had been heated to 90° C. for one hour and then left for a day, per gramme of Bacteria only 0·065 c.c. of oxygen was evolved. If the heating takes place in water the Bacteria may be killed without the absorptive power of the pigment being much affected. Thus a mass of *B. brunneus* from agar-cultures, after being killed by heating to 80° C. for one hour and then shaken up well with air for several

hours, could evolve per gramme of Bacteria 0·35 c.c. of oxygen. Similar cultures of *Bacillus brunneus* kept saturated with ether for two and four days could evolve per gramme of Bacteria after two days, in one case 0·45 c.c. of O, and in another 0·3 c.c., and after four days, in one case 0·43 c.c. and in another 0·24 c.c.

By extraction with alcohol it is possible to obtain the pigment along with some other extractives but free from all Bacteria, and to demonstrate that it still possesses the power of occluding and evolving oxygen. Thus if the alcoholic extract at (35° C.–40° C.) is allowed to evaporate to a small bulk and then water is added, a flocculent brownish precipitate is formed. The amount of precipitate thus obtained from 1 gramme of Bacteria was capable of evolving, after having been well shaken up with air, in one case 0·322 c.c., in another 0·25 c.c., and in a third 0·11 c.c. of oxygen.

A mass of *B. brunneus* was treated with alcohol at 40° C. till all pigment was extracted and the residue was colourless. The residue weighed moist but with no superfluous water or alcohol 2 grammes, and yielded 0·17 gramme of pigment and extractives. A fourth of this filtrate was, after precipitation with water, found to be capable of evolving per gramme of pigment 0·73 c.c. of oxygen. The remainder was allowed to evaporate to dryness and was weighed (weight = 0·13 gramme), and was found to be capable of evolving in one case 0·23 c.c. of oxygen and in another 0·21 c.c. Hence in the process of preparation and drying the extracted pigment is apt apparently to lose its power of occluding oxygen, and after keeping for a day or two the power is entirely lost. The solid pigment thus extracted was also examined by the gas-chamber method, and its power of evolving oxygen compared with that of wood-charcoal and oxyhæmoglobin. Both of these, as soon as the current of hydrogen has ceased, evolve sufficient oxygen to set the *Bacterium Termo* in the hanging-drop in a few minutes in active movement. A hemispherical piece of charcoal 0·9 cm. diameter and 0·2 cm. thick, in the gas-chamber (capacity 1·2 c.c. to 1·4 c.c.), continues for several hours to evolve oxygen in perceptible amount. For the first ¼ to ½ hour (though this phenomenon does not appear to be a vital one) oxygen nevertheless is evolved so rapidly and in such quantity that even in a continuous current of pure hydrogen the *B. Termo* continue to move. After being for 4 to 8 hours in hydrogen, however,

on clamping the charcoal is seen to be no longer able to evolve sufficient oxygen to cause *Bacterium Termo* to recommence to move.

With a piece of hæmoglobin the size of a small pea, made to a paste with water and placed in the chamber, after the current has passed through for $\frac{1}{4}$ hour the *B. Termo* are at rest. On clamping in 2–5 minutes the movement recommences and is soon quite active. After 10 hours the hæmoglobin can still evolve sufficient oxygen to cause the *B. Termo* to move in 10–15 minutes, and next day a weaker but still quite distinct evolution of oxygen can be detected.

Wood-charcoal, therefore, in an atmosphere of hydrogen evolves nearly all its contained oxygen rapidly and suddenly in the first hour or so, and the last traces more slowly in the succeeding 3 or 4 hours. Oxyhæmoglobin, on the other hand, evolves its oxygen more slowly at first, but the evolution of oxygen remains for a long time constant and may persist for a day or more. The evolution of oxygen from a mass of the coloured Bacteria is distinctly more active during the first hour, but then remains fairly constant for a few hours, then gradually weakens, but in some cases after 6 to 8 hours is still perceptible. A portion of this difference may be due to the greater impermeability of the pasty mass of hæmoglobin employed allowing a longer retention of the stored oxygen.

Hoppe Seyler * states that 100 grammes of oxyhæmoglobin, if dissolved in water, can evolve in vacuum 156 c.c. of oxygen, whereas Hüfner † finds that 1 gramme of oxyhæmoglobin can only evolve 1·2 c.c. of oxygen. Apparently oxyhæmoglobin can hold more oxygen when in solution than when dry; but even the dry hæmoglobin seems to have a greater power of occluding oxygen than the extracted bacterial pigment has. Thus an equal amount of the latter shows only a relatively weak evolution of oxygen lasting for a few hours, and intermediate in character between that from charcoal and hæmoglobin. There can be little doubt, however, that the oxygen occluded by the bacterial pigment is held in a similar manner to that in which

* Hoppe Seyler, Chemische Analyse, 6te Auflage, 1893, p. 275.

† Hüfner, in Zeitschrift f. physiol. Chemie, Bd. i. S. 317 & 386; Bd. iii. S. 1 (1879).

it is held by hæmoglobin, but differs in so far as the loss of the absorbed oxygen does not involve any perceptible change in coloration.

The storing of oxygen by these coloured Bacteria must have some biological significance in their economy. At first sight it seems as if we had here a very plausible explanation of the phenomena of at least facultative anærobism and even of obligate anærobism also, and an explanation moreover coinciding with that originally given by Pasteur. Lehmann and Neumann state that 8 of the coloured Bacteria, all of which are normally completely ærobic, may develop under certain conditions as anærobes. It is possible that the explanation of this phenomenon might be due to the bacterial colonies being supplied with a store of reserve oxygen. Further consideration, however, points against this explanation. Thus the amount of oxygen stored up is relatively small and is, as has already been shown, used up by the respiration of the Bacteria in the course of 24 hours or so. Nevertheless the possibility remains that oxygen might still be present, held in a more strongly combined condition, which can be detected by none of the methods above described, but which is still available for the life and respiration of the Bacteria, and that this oxygen might suffice for the respiratory needs of the Bacteria when growing as anærobes.

Bacillus brunneus will not grow in an atmosphere of either H or CO_2. If colonies are allowed to develop on roll cultures on gelatine at 20° C. until they are clearly visible as small brown dots, on replacing the air in the culture-tubes by hydrogen all further growth ceases, *i. e.* the amount of oxygen stored up in the bacterial colony is insufficient to allow of its continuing to grow in an apparently anærobic manner.

A few experiments on the respiration of *B. brunneus* were carried out in the following manner:—A bouillon-culture is divided into five equal portions containing equal amounts of Bacteria, each 15 c.c. being placed along with 10 c.c. of air in a small glass bulb, the bent neck of which is closed by Hg. After a given length of time the enclosed gas is collected over Hg and analysed. The following are the results thus obtained:—

Time.	CO_2 present.	O present.	O absorbed.
4 hrs.	0·7 p.c.	20·4 p.c.	0·04 c.c.
8 „	1·0 „	19·4 „	0·14 c.c.
12 „	1·8 „	16·0 „	0·48 c.c.
12 „	1·75 „	16·4 „	0·44 c.c.
12 „	1·48 „	16·4 „	0·44 c.c.

The same facts are brought out by successive observation experiments made upon the respiration of the coloured Bacteria. The apparatus used for this purpose is worthy of recommendation on account of its extreme simplicity. A small short-necked flask has a glass tube ground to fit the neck and projecting for some distance into its interior. The flask contains sterilized bouillon, and after inoculation is left in an almost horizontal position with the mouth closed by a plug of cotton-wool until the Bacteria have developed.

Sterilized air is then drawn through the flask at short intervals of time for an hour or two, and the latter then inverted over Hg, covered by a film of water. A sample of the air enclosed can be taken directly from the flask and analysed in the Bonnier and Maugin's apparatus, by closing the mouth of the flask with the finger and immersing it in the cup over the entrance-tube and then drawing in a small quantity of gas. A sample at once taken and analysed must give the composition of ordinary air. Then after a given length of time, by gentle agitation and by warming the flask with the hand and allowing it to cool again, a complete admixture of the gas in the flask with that in the relatively short and broad tube is assured. A sample is now taken and analysed, and after a further five minutes another sample is analysed. The mean of the two analyses, which should not vary from one another more than a small fraction of a per cent., is taken as representing the composition of the air at the given time.

For this purpose fairly old cultures containing an abundance of pigment, but in which a portion of the bacterial material is no longer living, were employed.

100 c.c. Bouillon-culture +80 c.c. air and nearly 2 grms. Bacteria moist weight.

Time.	Amt. of O.	Amt. of CO_2.	O absorbed per 3 hours.	CO_2 evolved per 3 hours.	$\frac{CO_2}{O}$
A.M. P.M. 9.30–12.30	20·5 p. c.	0·66 p. c.	0·24 c.c.	0·528 c.c.	$\frac{11}{5}$
P.M. P.M. 12.30–3.30	20·1 „	1·4 „	0·32 c.c.	0·672 c.c.	$\frac{12}{5}$
3.30–6.30	18·6 „	1·9 „	1·2 c.c.	0·4 c.c.	$\frac{1}{3}$
6.30–9.30	17·7 „	2·2 „	0·72 c.c.	0·24 c.c.	$\frac{1}{3}$
P.M. A.M. 9.30–9.30	15·24 „	2·75 „	0·492 c.c.	0·104 c.c.	$\frac{1}{5}$

100 c.c. of culture +60 c.c. air +nearly 2 grms. of Bacteria.

Time.	Amt. of O.	Amt. of CO_2.	O absorbed per 3 hours.	CO_2 evolved per 3 hours.	$\frac{CO_2}{O}$
A.M. P.M. 10—1	20·5 p. c.	0·76 p. c.	0·18 c.c.	0·456 c.c.	$\frac{13}{5}$
P.M. P.M. 1—4	20·0 „	1·5 „	0·30 c.c.	0·444 c.c.	$\frac{7}{5}$
4—7	18·3 „	1·98 „	1·02 c.c.	0·288 c.c.	$\frac{2}{7}$
7—10	16·9 „	2·30 „	0·78 c.c.	0·192 c.c.	$\frac{1}{4}$
P.M. A.M. 10—10	14·7 „	2·82 „	0·324 c.c.	0·078 c.c.	$\frac{1}{4}$

In a confined space, therefore, *Bacillus brunneus* at first respires at the expense of the oxygen held by the bacterial pigment, the respiratory quotient $\frac{CO_2}{O}$ being much greater than unity. After about 6 hours this oxygen has been apparently used up, and the respiratory quotient is now much less than unity ($\frac{1}{3}$ to $\frac{1}{5}$) and remains fairly constant.

Another conclusion to which these results, along with others which corroborate them, point, is that the amount of oxygen held by a mass of coloured Bacteria and capable of providing it with a supply of respiratory oxygen is larger than that found by the quantitative calculations previously given.

A number of other coloured and uncoloured Bacteria were examined both dead and living, either by the Bacterium method or by the analytical method or both, but in no case could any

power of occluding oxygen be detected. These are:—*Bacillus miniacus* (colour varying—red, purple, blue, white); *Bacillus cyanogenus* (blue); *Bacillus fluorescens*; *Micrococcus bicolor*; *Micrococcus candicans*; *Bacillus indigonaceus* (greenish blue); *Spirillum rubrum, S. undula, S. tenue*; *Bacterium Termo*; *Micrococcus prodigiosus* (red); *Bacillus pyocyaneus* (blue—yellow); *Chromatium Okenii* (purple); *Bacillus virens* (green); *Streptococcus varians* (green); and *Bacterium photometricum* (brownish red to reddish purple).

This property of absorbing and then, under reduced partial pressure, slowly evolving oxygen is a property not of all, but only of certain coloured Bacteria, in all of which the pigment is a Lipochrome. A very interesting question is whether this is a universal property of all lipochrome pigments—mono-, di-, and tetra-carotin. It is interesting to notice that Arnaud gives as the formula for carotin as extracted from Phanerogamic leaves $C_{26}H_{38}$; whilst Husemann states that carotin contains 6 p. c. of oxygen and gives it the formula $C_{33}H_{24}O_2$. It might be possible that the oxygen thus found by Husemann was held in a state of combination similar to that in which a portion of the oxygen is held by oxyhæmoglobin. The isolated bacterial pigment was found to evolve at most per gramme of dry weight 0·7 c.c. of oxygen. Supposing that, if pure, the amount evolved might have reached 1 c.c. and been nearly equal to that of hæmoglobin (4 grms.$=$4·2 c.c.), this would only have given per molecule of pigment (according to Husemann's formula) 0·032 of an atom of oxygen. The highest amount evolved from the Bacteria themselves per gramme being taken as 0·4 c.c., and supposing that the pigment forms about $\frac{1}{10}$ of this weight, and therefore in this case can evolve per gramme 4 c.c. of oxygen, this would, however, only give per molecule of pigment about 0·13 of an atom of oxygen. These amounts are quite insufficient to support the above hypothesis; and since the formula given by Arnaud seems to be the correct one, it is probable that Husemann did not work with the pure pigment. It is, however, very evident that further research in this direction from both a chemical and a physical standpoint is urgently needed *.

* The chemical and physical study of the bacterial pigments is being continued in the Botanical Laboratory of Leipzig University by Dr. Kunath and Prof. Pfeffer.

It is also quite within the bounds of possibility that this phenomenon may be more widely distributed throughout the organic kingdom than at first appears to be the case. Thus Beyerinck concludes, more from theoretical grounds than from practical experimentation, that certain anærobes require for their continued existence a trace of oxygen, but that a mere trace suffices, and this trace is stored up in the Bacteria themselves. Similarly with phosphorescent Bacteria, he finds that they continue to phosphoresce for a short time after all external oxygen has been removed. This last phenomenon, however, seems to be strictly comparable with the phenomenon known as intramolecular respiration, such as can go on for a time in any higher plant when all external oxygen has been removed. The absorption of oxygen by the coloured bacterial pigments above mentioned does not appear to be sufficient to account for the phenomena of anærobism, for all the stored oxygen is apparently used up in the course of a few hours. All of the above coloured Bacteria which can evolve oxygen, with the exception of *Bacillus brunneus*, about which nothing is said, are stated by Lehmann and Neumann * to be capable of developing as anærobes. Since, however, in the absence of oxygen no pigment is formed it appears that we have to do in this case simply with Bacteria which have two varieties, one being a pigmented ærobe and the other a non-pigmented anærobe.

The theoretical discussion of these points might be much prolonged, but until further research in this direction has been completed, such discussion is unprofitable. As regards the various well-known phenomena which are grouped together under the name of intramolecular respiration, a few words may be said. The generally accepted view of this phenomenon is that it consists in a deoxidization and self-combustion or decomposition of the protoplasmic molecule, a slight production of CO_2 taking place at the expense of the combined oxygen held by the protoplasm. A quite feasible view is, however, that a portion of this oxygen at least might be held either in a condition of loose combination, as in hæmoglobin &c., or be simply occluded, as in charcoal or platinum-sponge. That the chlorophyll pigment has no power of holding oxygen in a state of loose combination is shown by the fact that the evolution of

* Lehmann & Neumann, Atlas und Grundriss der Bakteriologie: Wurzburg, 1896.

oxygen from an assimilatory cell or tissue ceases in the darkness generally in a few seconds, and at the outside in a minute or two. If, however, an actively assimilating cell be suddenly killed, it may continue for as long as an hour after death (*Bacterium Termo* method) to show a very faint evolution of oxygen. If a quantity of green algæ be killed by $HgCl_2$ whilst a current of hydrogen is being passed through, and the tube then soon sealed and heated to 90° C.–100° C., the dead algæ may apparently evolve per gramme of moist weight 0·005 to 0·007 c.c. of oxygen, an amount, however, which is almost within the limits of error. If these experiments are repeated with algæ kept in darkness during the whole time, or if the current of hydrogen is continued for 15–20 minutes after the algæ have been killed, no perceptible trace of oxygen is found. It is possible that a minute trace of oxygen is evolved from an assimilating cell which is suddenly killed in this manner, but there is no reason to suppose that the oxygen was anything else but dissolved oxygen derived from the previously active assimilation and permeating the cell-sap and protoplasm.

An observation, mentioned in a previous paper *, is interesting in this connexion, namely, *Chara*-filaments in a current of hydrogen cease to show rotation in one-third the time that they do if simply kept in perfectly oxygenless water in a closed cell. In the former case it has been shown (*l. c.*) that an assimilating cell brought into an atmosphere of hydrogen evolves oxygen for a short time more rapidly than normally. Hence it is possible that the above difference is due to the fact that the cell-protoplasm holds oxygen in two forms, partly in a loose, and partly in a strong combination; the former, in the absence of an external supply of oxygen, being used up first and the latter later. In a current of hydrogen the loosely-held oxygen would be evolved and lost, and hence rotation would cease sooner than if the *Chara*-filament were simply immersed in a closed cell in oxygenless water, where all the supply of combined stored oxygen is available for intramolecular respiration. Just as feasible an explanation, however, is that in the current of hydrogen all the oxygen which the cell contains, held merely in solution by the cell-sap &c., is rapidly evolved and lost, whereas in the oxygenless water practically none of this dissolved oxygen is lost, but

* "On Assimilatory Inhibition," in Journ. Linn. Soc. (Bot.) xxxi. (1896) p. 386.

all remains available for respiration, and only when it is used up does true intramolecular respiration commence.

A further discussion of this point is at present inadvisable, but there can be no doubt that, just as in the case of intramolecular respiration, when in the absence of free oxygen an evolution of CO_2 takes place at the expense of the combined oxygen held by the plasma, so in certain cases a special kind of respiration may take place for a short time after all external free oxygen has been removed—the oxygen contained in the CO_2 evolved being derived from a store of merely occluded oxygen, held either by the organism itself or by some product excreted by it.

Evolution of Oxygen by other Coloured Bacteria.

In these the pigment forms an integral part of the bacterial plasma, the oxygen being produced only by a process of assimilation, which requires an absorption of energy and ceases when the supply of radiant energy is cut off.

Van Tieghem * has described two green Bacteria, *Bacterium viride* and *Bacillus virens*. In the latter the formation of colourless spores and germination of these in light to form greenish *Bacillus*-rods was noticed. Van Tieghem concluded that the pigment was chlorophyll, and that the Bacteria could assimilate as green plants do, but did not produce any direct experimental proof whatever. The assumption that a green bacterium must contain chlorophyll and be able to assimilate is quite unjustifiable, for certain pathogenic, undoubtedly saprophytic or parasitic Bacteria can produce a green pigment; and Gayon has shown that it is possible to extract from a small *Bacterium Termo*-like form growing on milk a green crystallizable pigment, insoluble in water and soluble in ether, alcohol, benzine, &c. In these last forms, however, the pigment seems to be an excrete product, and not to form part of the bacterial plasma.

Engelmann † has, however, described an actively motile green bacterium which has the power of evolving in light minute traces of oxygen. The evolution of oxygen is extremely weak, and

* Van Tieghem, in Bull. Soc. Bot. France, xxvii. (1880) p. 174.
† T. W. Engelmann, in Bot. Zeit. 1882.

can only be detected by *Spirillum*. Engelmann calls the Bacterium *Bacterium chlorinum*, but it is probably the same form previously described by Van Tieghem as *B. viride*. Scarcity of material and the impurity of the water-cultures prevented Engelmann from extracting the pigment or examining it spectroscopically.

In a glass cylinder containing mud and stagnant water and exposed to diffuse daylight, the water became turbid and green to yellowish green in colour. Microscopical examination revealed the presence of an exceedingly numerous *Micrococcus*-form, occasionally isolated or in clumps, but generally forming irregular or twisted chains of generally 2–12, and more rarely 12–30, individuals. Examination with high powers showed the plasma of the bacterium to have a distinct greenish tinge. A very few other, but uncoloured, Bacteria were present, but no other green organism.

Later, in another culture a green *Bacillus*-form having the power of forming endospores, and corresponding in all respects with the *Bacillus virens* of Van Tieghem, was found. By means of *Spirillum* the power of these Bacteria to evolve oxygen when exposed to light could readily be demonstrated. The *Micrococcus*-form frequently formed large loose green flocks adhering to the sides of the cylinder. These gave almost perfectly pure masses of the green *Bacterium*. Portions of such, mounted either directly in water or in a little thin gelatine, showed at the edges an evolution of oxygen sufficiently strong to keep *B. Termo* in moderately active movement and ceasing in a few seconds to a minute in the darkness.

The extraction of the pigment could either be made from such material, or from the water in which the Bacteria were floating and which microscopical examination showed to contain no other green organism, by adding to it $\frac{1}{3}$ to $\frac{1}{2}$ its volume of alcohol. A greenish flocculent precipitate which slowly settles is formed, leaving a clear supernatant fluid which can be siphoned off. On warming the residue with alcohol a green extract is obtained, and on adding benzine the latter becomes dark green and shows the reddish fluorescence and the marked absorption-band in the red characteristic of chlorophyll. The fluid beneath is yellowish and may have a slight reddish tinge. Hence a trace of carotin may be present. If the green bacterial mass is treated with very dilute alkali and then ether is added, the latter acquires a

distinct yellowish or brownish tinge, which $+H_2SO_4$ or HCl turns emerald and finally bluish green, showing etiolin to be present. The green residue, on treatment with water or alcohol, yields up a bright emerald or deep bluish-green pigment = alkachlorophyll.

The colourless bacterial residues after extraction with alcohol were tested for cellulose and starch, but neither could be detected. The assimilatory product is therefore not starch, but is probably sugar.

The chlorophyll, whether extracted as alkachlorophyll or as chlorophyllan, when exposed to light in the presence of oxygen, becomes in an hour or two olive-green, and then commences to fade, in 4–12 hours is quite yellow, and in 2–3 days is almost or entirely colourless. In darkness it remains green longer. The rapid fading may be due to the presence of some organic substance extracted either from the bacterium itself or from the stagnant water.

Both of these green Bacteria therefore possess normal chlorophyll and are able to assimilate. They grow only in stagnant water, exposed to light, in which a little decomposing vegetable material is or has been present. They can grow in water in which no more than a mere trace of oxygen can possibly be present. If introduced into water containing inorganic salts only no growth takes place, and the Bacteria soon fall to the bottom and die. *Bacillus virens* may show a weak power of movement, but the *Micrococcus*-form is non-motile. It can nevertheless, when living, distribute itself through the different layers of the water in which it is growing and maintain itself at a given level. This is evidently due to its possessing a power of adapting its specific gravity to that of the fluid immediately around it.

In cultures kept in darkness the Bacteria retain their green colour for as long as two weeks, but gradually sink to the bottom and settle, having evidently also much diminished in amount, leaving a clear fluid above. On microscopical examination the deposited green film is seen to be composed largely of colourless and evidently dead forms. On bringing such cultures which have been for three weeks or longer in the darkness into light again in a week or so, the fluid becomes green and is found to contain the same green bacterium as was present previously. In sealed tubes along with a little hydrogen in darkness, the Bacteria

rapidly die, but in the light remain living and green—*i. e.*, are apparently in darkness ærobes, in light anærobes. It is, however, as erroneous to call such cases examples of anærobism in Bacteria as it is in green plants. A complete obligate anærobe is an organism which not only does not require any supply of free external oxygen, but is actually injured by the presence of such.

All attempts to isolate these green Bacteria by the ordinary agar or gelatine-plate method were at first unsuccessful. Plenty of uncoloured colonies develop, but these even in light, though they may in form closely resemble the green Bacteria, do not become green; and inoculation experiments from these on stagnant water which had been sterilized failed to produce any growth of the original green Bacteria. Isolation experiments by means of plates of agar and gelatine containing inorganic salts, or the filtered fluid from stagnant water, were more successful. From *Bacillus virens* cultures, *Bacillus* colonies were formed on plates exposed to light, which in most cases were distinctly yellowish and in a few cases slightly yellowish green. The *Bacilli* are often motile, and on plates of gelatine + inorganic salts ($K_3PO_4 . Am_2SO_4 . MsSO_4$) form peculiar, somewhat dumbbell-shaped concretions of $MgCO_3$. On re-isolating the bacilli on fresh plates, or on inoculating in culture-tubes, they develop as before, but now, even though exposed to light, are quite colourless. Inoculation from these on sterile water produced no green growth.

With the green *Micrococcus*-form similar results were obtained. Occasionally in both cases a yellowish coloration persists until the third inoculation; but from none of the growths on gelatine or agar could any distinct evolution of oxygen in light be detected. The colonies from the green *Streptococcus*-form are all in the form of *Micrococci* and not as chains. This, however, often takes place with *Streptococcus*-forms when cultivated on nutrient media. Apparently we have here an example of extreme pleomorphism—a bacterium which, under normal conditions, forms chains, is green, and can assimilate, when developed on nutrient media becomes colourless, loses the power of assimilation, and splits up into isolated *Micrococci*. It is interesting in this connexion to notice that a bacterium (*Streptococcus ochroleucus*, Hueppe) is known which in light turns yellow. It is possible that this may be a closely allied species, variety, or even perhaps the same bacterium as the above *Streptococcus*, to which the provisional name of *Streptococcus varians* may be

given. *S. varians,* in addition to the characters above described, forms thick-walled, colourless arthrospores, sometimes laterally, but generally intercalary to the chains, occasionally a pair being formed together.

Attempts were made to obtain direct analytical proof of the presence of the power of assimilation in these green Bacteria by enclosing a given quantity of an almost pure green water-culture in glass tubes with a given volume of gas to light, and in darkness, for 12 hours, then opening and analysing the enclosed gas.

It appears, therefore, as if under the most favourable conditions and using an atmosphere of hydrogen a trace of oxygen may

Amount of fluid.	Condition.	Gas enclosed.	Exposure.	CO_2 found.	O found.
50 c.c.	Living.	15 c.c. { p. c. 17·1 O. 14·3 CO_2.	Bright diffuse daylight.	2·9 p. c.	9·3 p. c.
50 c.c.	„	„	Darkness.	4·2 „	8·5 „
18 c.c.	„	7 c.c. H.	„	8·5 „	0·0 „
„	Killed by $HgCl_2$.	„	Light.	0·3 „	0·0 „
„	Living.	„	„	1·03 „	0·0 „
„	„	„	„	0·36 „	0·0 „
„	Thick dark green almost pure culture.	„	„	4·6 „	0·37 „
„	„	„	„	3·9 „	0·79 „
„	„	„	Darkness.	9·2 „	0·0 „

appear. In all cases, in light less CO_2 is evolved and less oxygen absorbed than in darkness; but this might be explained as being due to a direct action of light upon the respiration of the Bacteria, instead of being due to a certain amount of assimilation having taken place. The analytical results do not, therefore, form a certain and sure proof of the presence of assimilation. It is possible, however, that with perfectly pure cultures more certain results may be obtained.

Purple Bacteria.

Engelmann * ascribes to these the power of assimilation, the assimilatory pigment being bacterio-purpurin. One peculiarity of this pigment is that it has a marked absorption-band in the

* T. W. Engelmann, "Die Purpurbakterien und ihre Beziehungen zum Licht," in Bot. Zeit. Oct. 1885.

ultra-red; and according to Engelmann an evolution of oxygen is shown in this region, *i. e.*, when the plants are apparently in darkness.

Of the purple Bacteria the following were found, cultivated, and examined: *Chromatium Okenii*, Ehr., *Chromatium Warmingii*, Ehr., and *Bacterium photometricum*, T. Engelm.* These all grow in stagnant water containing a trace of SH_2 and exposed to light. On examining masses of these Bacteria by means of *Spirilla*, a distinct attraction of the latter can be seen to take place in light, which ceases in darkness. If the preparations have been freshly made, on the contrary, and still contain dissolved oxygen, the red Bacteria may be seen to exercise a repulsive effect upon the *Spirilla*. By means of *Bacterium Termo* in no case could any evolution of oxygen be detected, though the red Bacteria were examined with and without sulphur-grains, free, in masses, motile and non-motile, in gelatine preparations, and in water.

For its size, *B. photometricum* seems to possess a stronger power of "evolving oxygen" than *Chromatium Okenii*; but here also no evolution of oxygen could be detected with certainty by *Bacterium Termo*.

In a culture of *Chromatium Okenii* it was noticed that in bright light the clear surface zone free from colour was deeper than when in very weak light. The Bacteria seek out regions where a little oxygen is present, and avoid those where it is very abundant. Thus, if the cover is removed and the surface exposed freely to air, the upper clear zone becomes still broader. These phenomena were noticed by Engelmann, and are considered by him to form a proof of the evolution of oxygen by the purple Bacteria. A quite possible explanation of the phenomenon, however, is that in light the sensibility of the Bacteria to oxygen alters. In the presence of oxygen *Bacterium photometricum* is less sensitive to light than in the absence of oxygen. Hence it is also possible that exposure to light may increase the sensitivity to oxygen, especially as in the darkness in a few hours the Bacteria come to rest, their general sensitivity to oxygen and power of seeking out regions where the oxygen percentage is most suitable being lessened in weak light and in darkness finally ceasing. Both causes may

* The *B. photometricum* showed all the physiological peculiarities with regard to light ascribed to it by T. W. Engelmann, in Pflüger's Archiv f. d. ges. Physiol. Bd. xxx. p. 95.

operate, for in the darkness the Bacteria at first come nearer to the surface, as if owing to the cessation of the evolution of assimilatory oxygen, but after being in darkness for a longer time they tend to distribute themselves more evenly throughout the upper and lower layers, and after being in darkness for a day or two commence to sink to the bottom.

Various facts seem to indicate that the purple Bacteria are really possessed of an actual, though extremely weak, power of assimilation. Thus, like the green Bacteria, they can grow and multiply in fluids in which but a trace of organic material is present. For the life of the red Bacteria the presence of SH_2 is essential, whereas the green Bacteria, though they can withstand the presence of a trace of SH_2, thrive best in its absence. Winogradsky has shown that the sulphur Bacteria obtain their main supply of energy by the oxidation of the sulphur, derived from SH_2, which they contain. Hence, perhaps, the weaker power of assimilation of the red Bacteria as compared with the green ones, which are apparently dependent almost entirely, under normal conditions, upon the oxidation of the carbon obtained by assimilation for their supply of energy. In saturated SH_2 water, or in sealed tubes with pure SH_2, even if exposed to light, the red Bacteria die in a few days—*i. e.*, they are not really anærobes. If, however, kept exposed to light in sealed tubes containing a little H and a trace of SH_2, or in capillary tubes, or in closed cells, the Bacteria, especially *Bacterium photometricum*, may remain living and motile for weeks, and also divide and multiply, the oxygen necessary for both the sulphur and carbon respiration being produced by the Bacteria themselves. In darkness they are ærobes, in light apparently are anærobes.

That the red Bacteria do actually evolve CO_2 was proved by testing almost perfectly pure water cultures free from all SH_2 in the gas-chamber by the methods already described as well as by direct analysis. In light the amounts of CO_2 evolved and O absorbed are slightly less than in darkness, but in no case can any actual evolution of oxygen be detected analytically. With ordinary SH_2 containing cultures, the gas finally analysed always contains a little SH_2 derived from the enclosed fluid. In none of these Bacteria does the pigment appear to have any power of occluding oxygen. An evolution of oxygen so weak that it can hardly be detected by *Spirillum* cannot be detected by analysis. So far as the evidence goes, a qualified acceptance of the presence

of a power of assimilation in purple Bacteria is at present justifiable, but until further research has been made in this direction it cannot be regarded as a conclusively established fact. All attempts to isolate *Chromatium Okenii* &c., on agar &c., with and without SH_2, in darkness or in light failed.

It has been shown above that in certain coloured Bacteria an evolution of oxygen takes place because the pigment possesses the power of holding oxygen in a state of loose combination as hæmoglobin does, whilst in others the evolution of oxygen is the result of a process of assimilation, and takes place only when an absorption of radiant energy is able to take place. Beyerinck's classification of pigment Bacteria into parachromophores, chromophores, and chromopares does not seem to be a correct one. So far as at present appears, the only Bacteria in which the pigment forms an essential and integral part of the bacterial plasma is in those green chlorophyllous and red bacterio-purpurin containing Bacteria, in which it has apparently an assimilatory function. Even here, as has been shown, under abnormal conditions the formation of pigment may be suppressed. This in the case of *Streptococcus varians* is perhaps comparable with the degenerative changes which may be induced in the chlorophyll grains of *Elodea* and *Funaria* under somewhat similar abnormal conditions *. In all the other coloured Bacteria examined the pigment appears to be an excrete product. They may be divided into two classes :—(*a*) Those which form a lipochrome pigment insoluble in water and having the property of holding oxygen in a state of loose combination, and hence having an important biological significance, especially as regards the respiration of the Bacteria. (*b*) All other pigment-forming Bacteria, in which the pigment is often soluble in water and is an excrete product which is either functionless or the function of which has not as yet been discovered.

In (1) under normal conditions the pigment is always formed, and always has precisely the same colour. In 2 (*a*) under normal conditions the pigment is always formed, but its formation is more readily affected by external agencies, and varieties in which but little or no pigment is formed are rather readily produced. The colour of the pigment, as well as its amount, in many cases

* "On Assimilatory Inhibition," in Journ. Linn. Soc. (Bot.) xxxi. (1896) p. 422, *etc.*

varies somewhat according to the nutrient medium on which the bacterium is grown.

2 (*b*). The formation of pigment often takes place only under very specialized conditions, and colourless varieties are commonly very readily produced, which may have permanently lost the power of forming pigment even when brought under the most favourable possible conditions again (*Bacillus prodigiosus*). In many cases the pigment is excreted as a colourless chromogen, which later is oxidized and becomes coloured. Frequently the pigment may pass through a series of colours before it reaches its most highly oxidized condition. This class is simply a heterogeneous assemblage of all the other pigment-forming Bacteria; but a further classification is impossible until more is known about them. It is quite possible that in certain of them the pigment may have functions as important as in those coloured Bacteria which can evolve oxygen.

Conclusions.

A number of coloured Bacteria possess the power under ppropriate conditions of evolving oxygen in greater or less amount. In certain of these the oxygen evolved appears to be occluded oxygen absorbed from the air by the pigment-substance excreted by the Bacteria. The process is not a vital one. The substances contained in an alcoholic extract appear to have, though to a less extent, the same power of occluding oxygen, but this property is soon lost.

The purple and green Bacteria, in which the pigment forms an integral part of the bacterial plasma, show, when exposed to radiant energy, a very weak evolution of oxygen, continuing for an indefinite length of time if conditions are favourable. In the former of these the assimilatory pigment is "bacterio-purpurin," in the latter chlorophyll. The process is a vital one, and the oxygen evolved is apparently derived from the assimilation of carbon dioxide.

Botanisches Institut,
Leipzig.

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The present number of the Journal is the second issued under the new regulations, which are as follow:—

Papers read from November and before the middle of January are published on **1st April.**

Papers read after the middle of January and before the end of April are published on **1st July.**

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NOTICE.

Vol. XXVI. is still in course of issue, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–219. (Complete.)

Vol. XXXII., Nos. 220–227. (Complete.)

Vol. XXXIII., No. 228 (the present Part).

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November 1. Price 4s.

THE JOURNAL

OF

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Vol. XXXIII. BOTANY. No. 229.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

NOTICE.

The remainder of Sir John Lubbock's paper will be issued in about a fortnight's time, the preparation of the numerous text-cuts having delayed the printing.

varies somewhat according to the nutrient medium on which the bacterium is grown.

2 (*b*). The formation of pigment often takes place only under very specialized conditions, and colourless varieties are commonly very readily produced, which may have permanently lost the power of forming pigment even when brought under the most favourable possible conditions again (*Bacillus prodigiosus*). In many cases the pigment is excreted as a colourless chromogen, which later is oxidized and becomes coloured. Frequently the pigment may pass through a series of colours before it reaches its most highly oxidized condition. This class is simply a heterogeneous assemblage of all the other pigment-forming Bacteria; but a further classification is impossible until more is known about them. It is quite possible that in certain of them the pigment may have functions as important as in those coloured Bacteria which can evolve oxygen.

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Botanisches Institut,
Leipzig.

Desmids from Singapore. By W. West, F.L.S., and G. S. West, A.R.C.S.

[Read 6th May, 1897.]

(Plates 8 & 9.)

The Desmids recorded in this paper were observed in a small collection of Algæ kindly made for us by H. N. Ridley, Esq., M.A., in Singapore. The number of species, forty-five, is not very great, but there are some very interesting ones, conspicuous among which are *Micrasterias anomala*, W. B. Turn., and *Cosmarium Askenasyi*, Schmidle. In 1895 a small paper appeared by Prof. Schmidle in Hedwigia, xxxiv., entitled "Einige Algen aus Sumatra"; and as little is known concerning the Algæ of this part of Asia except his list, the present paper is all the more interesting.

The following seven species found in the material from Singapore are also recorded from Sumatra:—*Euastrum obesum*, *E. ansatum*, *Cosmarium Askenasyi*, *C. connatum*, *C. Hammeri*, *C. pachydermum*, and *C. subglobosum*.

CYLINDROCYSTIS, *Menegh.*

1. C. crassa, *De Bary*, *Unters. Fam. Conj.* pp. 37, 74, t. 7. f. C 1–12.

Long. 31 μ; lat. 24 μ.

PENIUM, *Bréb.*

2. P. Libellula, *Nordst. in Vidensk. Meddel. Kjöb.* 1888, p. 184. *Closterium Libellula*, Focke. *Penium closterioides*, Ralfs.

Forma interrupta, *West, in Journ. R. Micr. Soc.* (1892) p. 721.

Long. 163 μ; lat. 29 μ.

Var. intermedia. *Roy, in Ann. Scott. Nat. Hist.* (1894) p. 252.

Long. 138 μ; lat. 21 μ.

3. P. Navicula, *Bréb. in Mém. Soc. Sci. Nat. Cherb.* iv. (1856) p. 146, t. 2. f. 37.

Forma GRANULATA. (Pl. 8. fig. 10.)

Forma cum membranâ regulariter et dense granulatâ, polis glabris.

Long. 63 μ; lat. 16 μ; lat. apic. circ. 7 μ.

4. P. CRASSIUSCULUM, *De Bary, Conj.* p. 73, t. 5. ff. 5–7.

Long. 64 μ; lat. 23 μ.

5. P. AUSTRALE, *Racib. in Rosprawy Akad. Umiej. Krakow. Wydziat nat.-przyn.* Ser. II., ii. (vol. xxii.) p. 367, t. 6. f. 27.

Long. 65–69 μ; lat. 38–40 μ; lat. isthm. 37 μ. (Pl. 8. fig. 16.)

The specimens observed are exactly typical as regards form, but they are more minutely punctate and the glabrous zone is narrower than in the type.

Cosmarium subturgidum, Schmidle [*Disphinctium subturgidum*, W. B. Turn.], f. *minor*, Schmidle, in Hedwigia, xxxiv. (1895) p. 300, t. 4. fig. 2, seems to us much nearer *in form* to *P. australe* than to *C. subturgidum* although the chromatophores seem to differ.

Schmidle remarks (in Engl. Bot. Jahrb. xxiii. (1896) p. 256) that *C. zonarium*, West & G. S. West, in Trans. Linn. Soc. Ser. II., Bot. v. (1895) p. 71, pl. 8. f. 13, is the same as *C. subturgidum*, var. *minor*. It is certainly very near his variety, and has the same arrangement of the chlorophyll, but we are sure that *C. zonarium* is a very different plant from *C. subturgidum*; the form is quite different, so is the size and so are the markings. This we were certain of at the time we described the former.

6. PENIUM sp.

Long. 17·5–19 μ; lat. 7·5–8·5 μ.

A few specimens only were seen of this small species; it is very slightly constricted in the middle, and the poles are rounded and a little truncate.

CLOSTERIUM, *Nitzsch.*

7. C. DIDYMOTOCUM, *Corda, Alm. de Carlsbad* (1835), t. 5. ff. 64, 65; *Ralfs, Brit. Desm.* p. 168, t. 28. f. 7 *a* et *b*.

Var. TROPICUM, n. var.

Var. ventre subrecto, dorso convexiori, polis dilatatis incrassatis; membrana glabra, lutea vel luteo-brunnea.

Long. 238–309 μ; lat. 36–44 μ; lat. apic. 17–19 μ.

8. Closterium subcapitatum, n. sp. (Pl. 8. figs. 1–3.)

Cl. mediocre; cellulis diametro circiter 11plo longioribus, subrectis, ventre recto vel leviter concavo, dorso convexo et in medio retuso, polos versus attenuatis, polis valde dilatatis (subcapitatis); membrana admodum punctata, luteola vel luteo-fuscescens, polis bene fuscis.

Long. 253-265 μ; lat. max. 13–25 μ; lat. med. 21-23 μ; lat. apic. 11 μ.

The strongly punctate membrane sometimes gives the margin a rough appearance. This species might be compared with *C. balmacarense*, W. B. Turn., in Naturalist (1893), p. 347; Roy and Bisset, in Ann. Scot. Nat. Hist. (1894) p. 243, t. 4. f. 6.

9. C. Legumen, n. sp. (Pl. 8. figs. 5–7.)

C. submediocre, subrectum: cellulis diametro 5–6plo longioribus, ventre recto, dorso leviter convexo, polos latos versus sensim attenuatis, polis rotundo-truncatis et levissime retusis; membrana hyalina, achroa, glabra; pyrenoidibus in serie unicâ, in semicellulâ unâquâque circiter 3.

Long. 153–176 μ; lat. 26–30 μ; lat. apic. circ. 10 μ.

We found this species originally from Huilla, Angola, West-Central Africa, but as it was only a single semicell we wished to see more of it before describing it.

It comes nearest to *C. rectum*, Gutw. (in Naklad. Akad. Umiej. Krakow (1896), p. 35, t. 1. f. 3). We consider that Gutwinski's species is probably a form of *Penium Libellula* (syn. *P. closterioides*); this form with the projecting median sutures we mentioned as occurring at Capel Curig, N. Wales (*vide* West, in Journ. R. Micr. Soc. (1890) p. 286).

10. C. Toxon, *West, in Journ. Linn. Soc. (Bot.)* xxix. (1892), p. 121, t. 19. f. 14.

Forma paullo brevior; membrana lutescens.

Long. 163 μ; lat. 9·5 μ; lat. apic. 5·5 μ.

11. C. pulchellum, n. sp. (Pl. 8. figs. 8–9.)

C. parvum; cellulis diametro circiter 7plo longioribus, leviter et regulariter curvatis, polos versus gradatim attenuatis, polis subobtusis; membrana glabra, fusca vel fusco-rubra; pyrenoidibus 2 in semicellulâ unâquâque.

Long. 75–84 μ; lat. 11 μ.

This species differs from *C. calosporum*, Wittr., in its coloured membrane, in being somewhat thicker and less curved, as well as in its blunter apices.

12. C. LAGOENSE, *Nordst. in Vidensk. Meddel. Kjöb.* (1869) p. 203. t. 2. f. 2.

Forma minus curvata.

Lat. 26 μ; apicibus 194 μ inter se distantibus.

13. C. SUBTRUNCATUM, n. sp. (Pl. **8**. fig. 4.)

C. mediocre; cellulis diametro 10plo longioribus, leviter curvatis, gradatim attenuatis polos versus, polis levissime dilatatis et late truncatis, ventre distincte sed leviter concavo; membrana luteola, delicate striolata, striis visis 25.

Long. 259 μ; lat. 26 μ; lat. apic. 13 μ.

This differs from *C. truncatum*, W. B. Turn. in Vet.-Akad. Handl. xxv. n. 5 (1893) p. 22, t. 22. f. 14, in its very regular curve, and in not being at all ventricose: the striolations are also more numerous, and the ends are slightly dilated on the dorsal side.

14. C. RALFSII, *Bréb.* (*Ralfs, Brit. Desm.* p. 174, t. 30. f. 2.)

Var. HYBRIDUM, *Rabenh. Krypt. Fl. Sachs.* p. 174; *Fl. Europ. Algar.* iii. p. 135.

Long. 306–345 μ; lat. 24–29 μ; lat. apic. 6·5–7·5 μ.

Forma MAJOR.

Long. 598 μ; lat. 44 μ; lat. apic. 11·5 μ.

15. C. STRIOLATUM, *Ehrenb.* (*Ralfs, Brit. Desm.* p. 170, t. 29. f. 2.)

A rather small form; long. 184–196 μ; lat. 25 μ; lat. apic. 10 μ.

PLEUROTÆNIUM, *Naeg.*

16. P. TRABECULA, *Naeg.*

Long. 392–426 μ; lat. bas. semicell. 30–32 μ; apic. 21–25 μ.

TETMEMORUS, *Ralfs.*

17. T. LÆVIS, *Ralfs, Brit. Desm.* p. 146, t. 24. f. 3.

Long. 82–87 μ; lat. 18·5–22 μ; lat. apic. 14 μ; lat. isthm. 1–7 19 μ.

EUASTRUM, *Ehrenb.*

18. E. GNATHOPHORUM, n. sp. (Pl. **9**. figs. 3, 4.)

E. mediocre, duplo longius quam latius, profunde constrictum, sinu angusto-lineari extremo subampliato; semicellulæ truncato-pyramidatæ, angulis inferioribus subrectangularibus, marginibus lateralibus biundulatis elevatione medianâ depressâ, angulis apicalibus subrotundatis et leviter incrassatis, apicibus convexis incisurâ medianâ profundissimâ et angustissimâ, serie verrucarum magnarum emarginatarum trium trans basin; a vertice visæ oblongo-rectangulares, nodis tribus ad polum unumquemque, incisuris tribus prope medium utrobique, incisurâ medianâ minus profundâ; a latere visæ ovato-oblongæ, angulis basalibus rectangularibus, lateribus retusis ad medium, angulis apicalibus rotundatis; membrana punctata.

Long. 63–65 μ; lat. 32–34 μ; lat. apic. 18–20 μ; lat. isthm. 12 μ; crass. 21 μ.

This characteristic species is nearest to *E. quadriceps*, Nordst. in Vidensk. Meddel. Kjöb. (1869) p. 216, t. 2. f. 5, with which it might be compared.

Compare also with *E. huillense*, West & G. S. West, in Journ. Bot. xxxv. (1897) p. 82, t. 366. ff. 15, 16.

19. E. SINUOSUM, *Lenorm. in Ralfs, Brit. Desm.* p. 85, t. 13. f. 5 *a*, *b*, *d*.

Var. REDUCTUM, *West & G. S. West*, *l. c.* p. 83.

Long. 46–59 μ; lat. 28–32·5 μ; lat. isthm. 7·5–9·5 μ; crass. 18 μ. (Pl. **8**. fig. 17.)

One specimen was noticed with the same number of scrobiculations as one figured by Raciborski (Ramiet. Wydz. III. Akad. Umiej. Krakow. xvii. t. 6. f. 9), but their arrangement was somewhat different.

20. E. ANSATUM, *Ehrenb.* (*Ralfs, Brit. Desm.* p. 85, t. 14. f. 2.)

Long. 88 μ; lat. 36 μ; lat. apic. 20 μ; lat. isthm. 15 μ.

21. E. OBESUM, *Joshua, in Journ. Linn. Soc.* (*Bot.*) xxi. (1886) p. 638, t. 23. ff. 19, 20.

Var. ROBUSTUM, n. var. (Pl. 8. fig. 20.)

Var. angulis basalibus semicellularum rectangularibus et rotundatis, apicibus latioribus.

Long. 86 μ; lat. 44 μ; lat. apic. 27 μ; lat. isthm. 11·5 μ.

This variety differs from var. *subangulare*, West & G. S. West, Trans. Linn. Soc. Ser. II. (Bot.) v. (1895) p. 50, t. 6. f. 15, in the broader apices and the different basal angles.

22. E. QUADRIOCULATUM, n. sp. (Pl. 9. figs. 5, 6.)

E. submediocre, circiter duplo longius quam latius, profunde constrictum, sinu angusto-lineari extremo subampliato; semicellulæ subtrilobatæ, lobis lateralibus emarginatis et lateribus convergentibus sursum, lobo polari subrectangulari angulis rotundatis, incisurâ medianâ profundâ lineari, in centro tumoribus binis horizontaliter dispositis; a vertice visæ ellipticæ, in medio utrobique tumoribus binis instructæ; a latere visæ truncato-ovatæ, tumore prope medium utrobique; membrana punctata.

Long. 38–40 μ; lat. 20–22 μ; lat. apic. 12·5–14·5 μ; lat. isthm. 5·5–6·5 μ; crass. 15·5 μ.

23. E. COSMARIOIDES, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. (1895) p. 54, t. 6. f. 23.

Var. CURTUM, *West & G. S. West, in Journ. Bot.* xxxv. (1897) p. 84.

Long. 18–22 μ; lat. 18–19 μ; lat. apic. 16–18 μ; lat. isthm. 5–5·5 μ; crass. 11 μ. (Pl. 8. figs. 18, 19.)

In front view the specimens from Singapore correspond exactly with those from Africa, but differ somewhat in the other views. The vertical view is elliptical and is without the swelling on each side possessed by the original examples.

24. E. DENTICULATUM, *F. Gay, in Bull. Soc. Bot. France,* xxxi. (1884) p. 335.

Long. 20 μ; lat. 15 μ; lat. isthm. 3·5 μ.

25. E. BINALE, *Ehrenb.* (*Ralfs, Brit. Desm.* p. 90, t. 14. f. 8.)

Var. ELOBATUM, *Lund. Desm. Suec.* p. 23, t. 2. f. 7.

A form not quite agreeing with Lundell's figure; long. 23 μ; lat. 18·5 μ; lat. apic. 13 μ; lat. isthm. 5·5 μ. (Pl. 8. fig. 11.)

MICRASTERIAS, *Ag.*

26. M. Möbii, *nob.*

Euastrum verrucosum, Ehrenb. var. *Möbii*, Borge, in Bihang K. Sv. Vet.-Akad. Handl. xxii. no. 9, p. 13, t. 2. ff. 18, 19.

E. verrucosum, forma, Möb. Austr. Süssw. Alg. ii. p. 340, t. 2. f. 21.

Var. Ridleyi, n. var. (Pl. 9. fig. 2.)

Var. major, semicellulis cum lobo polari altiori et convexiori (sed in medio leviter retuso), incisurâ infra apicem latiori et minus profundâ, lobis lateralibus minus productis, sinu valde aperto extrorsum; membrana scrobiculata, scrobiculis in centro multe majoribus.

Long. 135 μ; lat. 102 μ; lat. apic. 76 μ; lat. isthm. 36 μ; crass. 57 μ.

We do not consider that the var. *Möbii*, Borge, of *Euastrum verrucosum* belongs to that genus, much less to that species. The polar lobe is that of a *Micrasterias* and not that of an *Euastrum*. The characters of *M. Möbii* are so different from those of *E. verrucosum* that we fail to see how it came to be placed under the latter species.

The variety seen by us was scrobiculate and not granulate, the scrobiculations being much larger in the centre of the semicells; Borge describes his specimens as granulate. The magnifications of Borge's figures (*l. c.*) are incorrect, as proved by his measurements in the text.

27. M. anomala, *W. B. Turn. in Vet.-Akad. Handl.* xxv. no. 5, (1893) p. 97, t. 22. f. 1.

M. apiculata, Menegh. forma, Joshua, in Journ. Linn. Soc. (Bot.) xxi. (1886) p. 636, t. 22. f. 13.

M. apiculata forma *Joshuæ*, Toni et Levi, in Notarisia (1886), p. 91.

Long. 218 μ; lat. 150 μ; lat. isthm. 44 μ. Lat.: long. = 1 : 1·45.
" 227 μ; " 160 μ; " " 40 μ. " : " = 1 : 1·42.
(Pl. 9. fig. 1.)

The specimens observed of this fine species were rather large ones and were much more regular in form than Turner's figure, the polar lobes have a distinct subrectangular basal portion which causes them to be more produced, the lateral divisions are less deep and the sinus is more open. These characters, however, are not of varietal importance, because, judging from Turner's figure of the typical form (*l. c.* fig. 1 *a*), we should imagine that

his specimens had been somewhat damaged (*vide* his drawing of the polar lobe). Two whole specimens were seen; these were practically identical in form, but the arrangement of the central processes was different. In one there was a transverse row of 5 processes across the basal part of the semicell, the central one being much the largest and showing indications of a division into two. In the other, there were but 4 processes in the transverse row, the two median ones being more or less irregularly divided.

We consider that Turner is quite mistaken in supposing that the processes are tubular; they are hollow just like those of *M. americana*, *M. Nordstedtiana*, and *M. muricata*; moreover, from a physiological standpoint they could not be "tubular"! The membrane was quite smooth and of a pale yellow colour. We have no doubt that the *M. apiculata, forma* of Joshua, was a damaged form of the same species as *M. anomala*, W. B. Turn. The finding of the plant from Singapore extends its distribution eastwards, it being previously recorded from E. India (*Turner*) and Burmah (*Joshua*).

28. Micrasterias rotata, *Ralfs, Brit. Desm.* p. 71, t. 8. f. 1.
Long. 208 μ; lat. 165 μ; lat. isthm. 29 μ.

29. M. Thomasiana, *Archer, in Proc. Dubl. Nat. Hist. Soc.* (1862) p. 72, t. 2. ff. 1–5.

Two forms of this were seen:

(1) A form a little narrower than the type and destitute of the superficial apiculate elevations; the membrane was finely scrobiculate.

Long. 192 μ; lat. 150 μ; lat. isthm. 27 μ. Lat.: long.=1 : 1·28.

(2) A form without the central one of the three median projections; the superficial apiculate elevations were also absent, but on one semicell a large apiculate elevation was present at the middle of the lateral lobe bordering upon the polar lobe and close to its margin.

Long. 175 μ; lat. 144 μ; lat. isthm. 26 μ. Lat.: long.=1 : 1·20.

COSMARIUM, *Corda*.

30. C. Hammeri, *Reinsch, Algenfl. Frank.* p. 111, t. 19. f. I.
Long. 23 μ; lat. 17 μ; lat. isthm. 5·5 μ; crass. 10 μ.

31. COSMARIUM ANCEPS, *Lund. Desm. Suec.* p. 48, t. 3. f. 4.

Forma paullo major, apicibus latioribus, angulis basalibus rotundatis et levissime productis.

Long. 39 μ; lat. bas. semicell. 18 μ; lat. apic. 15 μ; lat. isthm. 9·5 μ.

(Pl. 8. fig. 12.)

32. C. URCEUM, n. sp. (Pl. 9. figs. 8, 9.)

C. parvum, duplo longius quam latius, profundissime constrictum, sinu angusto-lineari ad extremum subampliato; semicellulæ anguste truncato-pyramidatæ, lateribus retusis, angulis basalibus rectangularibus leviter rotundatis, angulis superioribus subrotundatis, apicibus leviter retusis; a vertice visæ oblongo-ellipticæ; a latere visæ oblongæ, apicibus rotundatis; membrana minute punctata.

Long. 32·5–34·5 μ; lat. bas. semicell. 15–16 μ; lat. apic. 9·5–10·5 μ; lat. isthm. 4 μ; crass. 9·5 μ.

Compare with *C. angustatum*, Nordst.

33. C. PARVULUM, *Bréb. in Mém. Soc. Sc. Nat. Cherb.* iv. (1856) p. 133, t. 1. f. 18.

A curious abnormal cell of this was seen.

Long. semicell. 9·5 μ; lat. 9·5 μ.

34. C. STRIATUM, *Boldt, in Öfvers. Vet.-Akad. Förh.* (1885) no. 2, p. 104, t. 5. f. 9.

Long. 12·5 μ; lat. 12 μ; lat. isthm. 4·5 μ; crass. 6 μ.

35. C. PACHYDERMUM, *Lund. Desm. Suec.* p. 39, t. 2. f. 15.

Var. MINUS, *Nordst. Norg. Desm.* p. 18, t. 1. f. 7.

Long. 56 μ; lat. 48 μ; lat. isthm. 18 μ; crass. 28 μ.

36. C. OBSOLETUM, *Reinsch, Algenfl. Frank.* p. 110, t. 9. f. 5.

Long. 57–60 μ; lat. 67–71 μ; lat. isthm. 33–35 μ; crass. 36 μ.

The specimens were often of a yellow or yellow-brown colour, and the basal angles of the semicells were thickened (not mamillate); extending through this thickening was a marked conical pore which was broadest towards the interior of the *Cosmarium*.

37. C. ASKENASYI, *Schmidle, in Hedwigia* (1895), p. 304, t. 4. f. 7.

Long. 142–158 μ; lat. 121–137 μ; lat. isthm. 38–53 μ; crass. 75 μ.

The numerous examples of this species seen by us were all broader than the forms described from Sumatra by Schmidle. The membrane is scrobiculate, the scrobiculations being larger over the central thickened area of each semicell, and there are fine punctulations between these scrobiculations; in age the membrane becomes yellow. The granules are conical and vary somewhat in length; the breadth of the isthmus varies considerably, and the apices of the semicells are in all cases slightly truncate.

As we have previously pointed out (Trans. Linn. Soc. Ser. II. (Bot.) v. (1895) p. 229, footnote), *C. dentatum*, Wolle (*cfr.* West & G. S. West, l. c. p. 249, t. 15. ff. 10, 11), is by far the nearest ally of this species. Schmidle represents the conical granules too large relatively to the magnification of the cells; the figures given by Borge in Bihang Vet.-Akad. Handl. xxii. no. 9, t. 3. ff. 35, 36, are more correct in this respect, but the granules are more acute than any we have seen.

C. Stuhlmannii, Hieron. (in Engler, Die Pflanzenwelt Ost.-Afrik. u. d. Nachbargebiete, Theil C, 1895, p. 19), is most probably a form of this species.

38. Cosmarium margaritatum, *Roy et Biss. in Journ. Bot.* xxiv. (1886) p. 194.

Long. 65 μ; lat. 57 μ; lat. isthm. 25 μ.

39. C. subdecoratum, n. sp. (Pl. 8. fig. 13.)

C. mediocre, $1\frac{1}{4}$plo longius quam latius, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ truncato-pyramidatæ, angulis inferioribus et superioribus rotundatis, lateribus convexis, apicibus subrectis; membrana granulis quincuncialiter ordinatis, seriebus horizontalibus circiter 7, seriebus obliquis circiter 10, scrobiculis triangularibus 6 circa granulum unumquemque; a vertice visæ oblongæ, polis rotundatis.

Long. 66 μ; lat. 53 μ; lat. isthm. 17·5 μ; crass. 29 μ.

This differs from *C. decoratum*, West & G. S. West in Trans. Linn. Soc. Ser. II. (Bot.) v. (1895) p. 61, t. 7. f. 21, in its smaller size, its deeper constriction, its much fewer granules, and in its vertical view; moreover, the sides and not the angles of the triangular scrobiculations are directed towards the granules. It differs from *C. multiordinatum*, West & G. S. West in Journ.

Bot. xxxv. (1897) p. 121, t. 367. f. 8, in the narrower apices of the semicells, the different vertical view, and the triangular scrobiculations, which are differently arranged.

40. Cosmarium punctulatum, *Bréb. in Mém. Soc. Sc. Nat. Cherb.* iv. (1856) p. 129, t. 1. f. 16.

Var. depressum, *W. B. Turn. in Vet.-Akad. Handl.* xxv. (1893) n. 5, p. 54, t. 8. f. 16.

Forma minor. Long. 17·5 μ; lat. 15·5 μ; lat. isthm. 4 μ; crass. 8·5 μ.

41. C. trachypolum, n. sp. (Pl. 8. figs. 14, 15.)

C. parvum, circiter $1\frac{3}{4}$plo longius quam latius, leviter constrictum, sinu lato aperto; semicellulæ rotundato-ovatæ, apicibus levissime truncatis, parte superiore semicellularum sparse minutissime granulatâ; a vertice visæ circulares.

Long. 29–30 μ; lat. 16–17 μ; lat. isthm. 11·5–13 μ.

Compare with *C. sparsipunctatum* (syn. *Disphinctium sparsipunctatum*, Schmidle, in Oesterr. bot. Zeitschr. xlv. (1895) p. 348, t. 15. ff. 1–6).

42. C. subglobosum, *Nordst. Alg. sandvic.* p. 14, t. 1. f. 13.

Forma minor.

Long. 24 μ; lat. 15·5 μ; lat. isthm. 14 μ.

43. C. connatum, *Bréb. in Ralfs, Brit. Desm.* p. 108, t. 17. f. 10.

Long. 69 μ; lat. 52 μ; lat. isthm. 44 μ.

44. C. Cucurbita, *Bréb.* (*Ralfs, Brit. Desm.* p. 108, t. 17. f. 7).

Long. 32 μ; lat. 15 μ; lat. isthm. 12·5 μ.

STAURASTRUM, *Meyen*.

45. S. decoratum, n. sp. (Pl. 9. fig. 7.)

S. parvum, $1\frac{1}{2}$plo longius quam latius, profunde constrictum, sinu angusto-lineari extremo subampliato; semicellulæ pyramidato-trapeziformes, angulis inferioribus superioribus rotundatis, lateribus retusis supra medium, apicibus leviter retusis; zonis latis granulorum altera trans partem basalem, altera trans partem apicalem, granulis in seriebus verticalibus ordinatis; a vertice

G.S.West ad nat. del.
A.T.Hollick lith.

West, Newman imp.

G.S. West ad nat. del.
A.T. Hollick lith.

West Newman imp.

DESMIDS FROM SINGAPORE.

visæ triangulares, lateribus convexis angulis leviter obtusis; membrana punctata inter granula.

Long. 34 μ; lat. ad bas. semicell. 23 μ; lat. apic. 18 μ; lat. isthm. 8·5 μ.

The margins of this species only appear rough near the angles.

EXPLANATION OF PLATES 8 & 9.

a, *a'* = cellula vel semicellula a fronte visa.
b = „ „ vertice „
c = „ „ latere „

All the figures are magnified 520 diameters.

Plate 8.

Figs. 1–3. *Closterium subcapitatum*, n. sp.
4. „ *subtruncatum*, n. sp.
5–7. „ *Legumen*, n. sp.
8–9. „ *pulchellum*, n. sp.
10. *Penium Navicula*, Bréb., forma *granulata*.
11. *Euastrum binale*, Ehrenb., var. *elobatum*, Lund., forma.
12. *Cosmarium anceps*, Lund., forma.
13. „ *subdecoratum*, n. sp.
14–15. „ *trachypolum*, n. sp.
16. *Penium australe*, Racib.
17. *Euastrum sinuosum*, Lenorm., var. *reductum*, West & G. S. West.
18–19. „ *cosmarioides*, West & G. S. West, var. *curtum*, West & G. S. West.
20. „ *obesum*, Josh., var. *robustum*, n. var.

Plate 9.

Fig. 1. *Micrasterias anomala*, W. B. Turn.
2. „ *Möbii*, nob., var. *Ridleyi*, n. var.
3–4. *Euastrum gnathophorum*, n. sp.
5–6. „ *quadrioculatum*, n. sp.
7. *Staurastrum decoratum*, n. sp.
8–9. *Cosmarium urceum*, n. sp.

On the Number of Sterigmata and Spores in *Agaricus campestris*. By E. Charles Horrell. (Communicated by Professor J. Bretland Farmer, F.L.S.)

[Read 3rd June, 1897.]

(Plate 10.)

Notwithstanding the fact that the common mushroom, *Agaricus (Psalliota) campestris*, has been described in very many text-books, there still exist various contradictory statements as to the number of spores borne on each basidium. For this reason and also because most of the statements were made some years ago, when the methods of preparation were not perhaps so good as they are today, it seemed advisable to carefully examine a number of specimens of different ages, in order to determine the actual amount of variation, if any, and thus if possible to set the matter at rest.

In the first English edition of Sachs's Text-book (1875), in the description of *Agaricus campestris* (p. 251), the following sentence occurs:—"Each basidium produces in this species only two, in other Hymenomycetes usually four spores." Here also is the well-known figure, which has been copied into almost all the succeeding text-books. In the following year Mr. Worthington G. Smith, writing on the structure of the Common Mushroom ('Gardener's Chronicle,' 1876, p. 456), says:—"The spores in all the mushroom tribe are produced in clusters of four on each basidium; but on the common mushroom, and all its varieties, as far as I have seen, these four spores are generally produced two at a time, and as the first two drop off the last two appear, so that it is seldom that more than two are seen *in situ* at the same time." He adds, "The phenomenon . . . . has been quite erroneously interpreted by Prof. Sachs." Mr. W. G. Smith gives figures showing spores being produced two by two on each basidium, but the form of the basidia figured by him does not in the slightest degree resemble that of the basidia of *Agaricus campestris*. In 1884 Hesse, in a long paper on the structure of the Agarics *, for the purpose of which he examined

* "Beiträge zur Classification der einheimischen Agaricineen auf anatomische Grundlage." (Verhandl. bot. Vereins Brandenburg, 1884, p. 110.)

some 200 species, paid special attention to this question, and says that in *Agaricus campestris* he had never seen a basidium with more than two sterigmata, and never any signs of two crops as described by W. G. Smith.

De Bary, writing in 1887 *, observes that there are only two sterigmata in *Calocera* and *Dacryomyces*, but does not mention the mushroom. The next writer to touch upon the question was Mr. G. Massee, who, in a note to a "Monograph of the *Thelephoreæ*" † referring to Sachs's statement that only two spores are developed in the mushroom, remarks:—"This is not correct; the basidia of *Agaricus campestris* have four sterigmata, each producing a spore; nevertheless this strange error has been repeated and accompanied by the equally incorrect woodcut in several English works on Botany." Finally, Zopf in Schenk's 'Handbuch,' in 1890, states (vol. iv. p. 631) that in *Agaricus campestris* there are only two sterigmata.

Most of the material at my disposal consisted of cultivated mushrooms of different ages. Small pieces bearing lamellæ were cut off and fixed for about 24 hours in Flemming's weak solution, or in a concentrated solution of corrosive sublimate containing one per cent. of glacial acetic acid. Flemming's solution was found to give far better results than corrosive sublimate. After fixation, the material was well washed in water and brought gradually through increasing strengths of spirit to absolute alcohol; then through 50 per cent. alcohol and chloroform, through several changes of chloroform to half chloroform and paraffin, and finally to paraffin. Thin sections were then made by the Cambridge Rocking Microtome, and after being floated out on the surface of warm water, they were fastened on the slide by means of albumen fixative. The paraffin, after careful drying, was removed by xylol, and the sections were then stained on the slide. The principal stains used were gentian violet, either alone or in combination with Congo red or fuchsin, Hartog's carmine and nigrosin as recommended by Wager ‡, Mann's eosin and toluidin blue, Heidenhain's hæmatoxylin with orange G or Congo red.

* Comp. Morph. Fungi, &c., Eng. ed. 1887, p. 63.

† Linn. Soc. Journ. (Bot.) xxv. (1890) p. 107.

‡ "Structure and Reproduction of *Cystopus candidus*," Ann. Bot. vol. x. p. 294.

Of these gentian violet and Congo red gave decidedly the best results; the red staining the walls very sharply and making the sterigmata very distinct, whilst the gentian stained the nuclei only. This combination, however, was difficult to use, as the Congo red quickly washed out the gentian. Staining for 24 hours in a strong aqueous solution of gentian violet, followed by about 10–20 seconds in a spirit solution of Congo red, gave the finest results.

Some of the pieces were cut so as to show the basidia in longitudinal section, and others so as to show the tops of the basidia with their sterigmata in end-on or surface view.

In all the preparations there could be no doubt that on nearly all the basidia there were only two sterigmata developed, those bearing three sterigmata not forming more than 1 or 2 per cent. of the whole, and those with four not 1 per cent. Notwithstanding this small *relative* proportion, however, the entire number of basidia seen bearing undoubtedly 3 and 4 sterigmata was considerable, but in no case was there any evidence of the spores being borne in two successive generations as W. G. Smith has described. When 3 or 4 sterigmata were present they all seemed to be of the same age, and basidia bearing more than two sterigmata were not more frequently present in old plants than in young ones. The basidia vary somewhat in shape, and considerably in size, even in the same lamella. They are club-shaped bodies about 25–34 μ in length and from $6\frac{1}{2}$–13 μ in width at the club-shaped end, and about 3 μ at the attenuated base. Each sterigma is a conical outgrowth, tapering from a round base to a fine point on which the spore is borne, and varies in length from $2\frac{1}{2}$–5 μ. Between the basidia are numerous nearly cylindrical paraphyses about 20–27 μ in length and 5 in width. The dark brown elliptical spores are, when ripe, about $8\frac{1}{2}$ μ by $6\frac{1}{2}$. Below the hymenium are several layers of pseudo-parenchymatous cells, succeeded by the cells, running longitudinally, of the trama.

My investigations have clearly shown that, at any rate in cultivated specimens, some degree of variation does occur. There does not seem to be any reason why the same should not happen in wild plants, and possibly to a still greater extent, for their environment is subject to greater variation (*e. g.* in the

Hannart

AGARICUS

matter of soil, climatic conditions, &c.) than is the case with plants cultivated in mushroom-houses. Thus it may be possible to reconcile the conflicting statements of Massee and Hesse, both of whom are apparently writing of the mushroom growing in a wild state.

For purposes of comparison a number of species belonging to other genera and subgenera were examined, all of which uniformly possessed four sterigmata. Amongst the species of the Hymenomycetes which have been described up to the present as usually bearing only two sterigmata on each basidium are *Agaricus (Psalliota) campestris*, *Ag. (Psalliota) sylvaticus*, *Ag. (Mycena) corticola*, *Ag. (Mycena) hiemalis*, *Ag. (Naucoria) tenax*, *Hypochnus bisporus*, *Pistillaria micans*, *Craterellus cornucopioides*, and the genera *Guepinia*, *Calocera*, and *Dacryomyces*.

EXPLANATION OF PLATE 10.

Fig. 1. Portion of the hymenium of *Agaricus campestris*, showing basidia bearing spores of different ages. One basidium is shown bearing three nearly ripe spores, and another bearing four very young ones.

Fig. 2. Basidia in longitudinal section, with spores *in situ*.

Fig. 3. Basidia in transverse section (diagrammatic), showing the arrangement of the sterigmata.

All figures are magnified 1200 diameters, and were drawn under the Abbé Camera Lucida.

Primula elatior in Britain : Its Distribution, Peculiarities, Hybrids, and Allies. By MILLER CHRISTY, F.L.S.

[Read 17th June, 1897.]

(With a MAP.)

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I. *Introductory Remarks.*

THE object of the following paper is to state the results of a number of observations made by myself during the last eighteen years upon certain points in connection with the natural history in Britain of the above-named species and its allies. Although the facts to which I have to call attention are not altogether new and unknown, they are, at least, unfamiliar to many botanists and misunderstood by most.

The five British members of the genus *Primula*, though readily distinguishable from each other when found under normal conditions, present many perplexing intermediate forms due to

hybridism. It is well, therefore, to present at the outset the following clear tabular statement which I have compiled :—

British Members of the Genus Primula.

Nos. in "Lond. Cat." 9th Ed. (1896).	Scientific name.	English Name and Description.	Census Number.
1061	**P. acaulis,** *Linn.*	**The Primrose.**	**111**
	× veris.	Hybrid with Cowslip *.	—
	"var. caulescens."	? Hybrid with Cowslip.	—
	× elatior.	Hybrid with Oxlip.	—
1062	**P. veris,** *Linn.*	**The Cowslip.**	**91**
	(×*acaulis*).	(*Hybrid; see above*).	—
	×elatior.	Hybrid with Oxlip.	—
1063	**P. elatior,** *Jacq.*	**The "True" or "Bardfield" Oxlip.**	**7**
	"var. *acaulis*."	Single-flowered Form.	—
	(×*acaulis*).	(*Hybrid; see above*).	—
	(×*veris*).	(*Hybrid; see above*).	—
1064	**P. farinosa,** *Linn.*	**The Mealy or Bird's-eye Primrose**	
1065	**P. scotica,** *Hook.*	**The Scottish Bird's-eye Primrose.**	**4**
	"var. acaulis."	Single-flowered Form.	—

* The "Common," "Spurious," or "Hybrid Oxlip."

It is with the first three species shown that I am alone herein concerned. They are of special interest because (as I shall show) each one of them enters into hybrid unions with the other two, producing more or less perplexing intermediate forms, and because (owing to this fact) the question as to whether they should be regarded as three distinct species or as varieties of one has been more often and more warmly discussed than is the case with any other equally-well-known British plants; while, for the same reason, their synonymy has become, I fear, inextricably confused. Linnæus regarded them as three forms or varieties of one variable species †; but, though this view was accepted until recent years, it is not endorsed by modern botanists. Of *Primula acaulis* and *P. veris*, I have little to say, except upon the hybrid

† 'Species Plantarum,' p. 204.

alliances into which they enter one with the other and with *P. elatior.* It is with the latter that I am chiefly concerned. As all three species are exceedingly well known by their vulgar, or English, names, I shall use these in speaking of them hereafter.

II. Primula acaulis *and* P. veris.

As every one is aware, both the Primrose and the Cowslip are very widely distributed and exceedingly abundant throughout Britain. The former may, indeed, be regarded as our best-known and most characteristic plant. Practically speaking, both species may be said to occur everywhere, though both are, for some not-very-easily-assignable cause, absent from certain limited districts. The Primrose has been recorded from no less than 111 of Watson's botanical "counties," while the Cowslip (which is, from some cause, more erratic and less wide in its distribution) has been recorded from 91, the total number of such counties being 112.

Perhaps no point in connection with these two species is so noticeable, next to their great abundance, as the fact that specimens may be commonly met with which represent almost every conceivable intermediate stage between the two type-forms. Thus the flowers are sometimes produced singly, like those of the Primrose; sometimes in umbels, like those of the Cowslip; and it is by no means unusual to find flowers of both kinds on the same plant. Often, even when a plant bears only umbellate flowers, the umbels are irregular, with pedicels springing singly from the sides of the peduncle below the umbel. The flowers themselves vary to an equal extent. Sometimes they differ but little from the Primrose type, but usually they more closely approach the Cowslip type, being smaller than those of the Primrose, with the darker yellow, brighter eye, and more inflated calyx of the Cowslip. When flowers of this type are borne in umbels (which is certainly the most usual form of the hybrid), we have the "Common," "Spurious," or "Hybrid Oxlip," which has received from botanists many names, such as *P. brevistyla*, *P. intricata*, *P. Thomasinii*, *P. variabilis*, *P. acaulis* var. *caulescens*, and a host of others. This is a handsome flower, decidedly more showy than either of its parents, and a great favourite in cottage gardens, where it often grows to a large size.

To such an extent, indeed, do the Primrose and the Cowslip

intergrade that (as stated above) some botanists have been led to regard the two as one highly-variable species. This, however, seems to me quite unjustifiable; for the intermediate forms are, without any reasonable doubt, hybrids; and, although hybridity among plants may certainly be regarded as evidence of more or less near relationship, few or none will argue that it necessarily shows specific identity.

There is, moreover, much circumstantial evidence that the intermediate forms are really of a hybrid nature:—

(*a*) That the hybrid is always present wherever the two reputed parents grow in close proximity;

(*b*) That it never occurs where either or both of the reputed parents are absent;

(*c*) That it is variable in form, presenting (as already stated) almost every conceivable intermediate form between the two reputed parents;

(*d*) That it is never abundant, and is always more or less scarce and sporadic in its appearance; and

(*e*) That it remains in flower (according to my observations) for a longer period than either of the two reputed parents, which may, I think, be regarded as probable evidence of sterility due to hybridism.

Moreover, direct evidence upon the point is forthcoming; for Darwin, by means of actual experiment, proved to his complete satisfaction that the "Common Oxlip" was really a hybrid *. It may, therefore, now be considered to be conclusively established that the many intermediate forms between the Primrose and the Cowslip are really hybrids.

As to which plant, if either, usually stands as the female parent, I am unable to say with certainty. I believe that both species do so occasionally, but the Primrose much the more frequently. This I infer from the fact that the hybrid plants are usually found growing among Primroses, and in places (such as woods and hedge-banks) specially suited to the Primrose; whilst they are comparatively seldom found growing among the Cowslips in open meadows. At the same time, it must be admitted that, in its inflorescence, the more common form assumed by these

* Journ. Linn. Soc., Bot. vol. x. (1868) pp. 437–451; and 'The Different Forms of Flowers, &c.' (1877) pp. 55–71.

hybrids (namely, the "Hybrid Oxlip" already mentioned) most nearly approaches the Cowslip, being umbellate, with bright yellow flowers and a large inflated calyx.

The Hybrid Oxlip, though so common and so generally distributed, cannot be regarded otherwise than as a comparatively-rare plant, when the enormous abundance of the two parent species and the close proximity in which they are frequently found are taken into consideration. This may, however, be to some extent due, not so much to any reluctance on the part of the two species, or of either, to enter into a hybrid alliance, but to the fact that the flowering-times of the two species are not exactly synchronous. The Primrose is everywhere in full flower at least a fortnight or three weeks earlier than the Cowslip, and the flowers of the former have usually begun to fade before those of the latter are fully expanded.

In the 'London Catalogue' (9th ed., 1896) and many botanical books, one finds recorded under the heading Primrose a "var. *caulescens*," which is supposed to differ only from the type-form in that it bears its flowers, not singly, but in umbels. I have never been quite able to satisfy myself that such a form ever really occurs in a state of nature. I am inclined to think that such plants are in all cases due to the seductive hybridizing influence of the Cowslip, and that this so-called "variety" is, therefore, only another form of the Common (Hybrid) Oxlip. It may be, however, that such a variety really exists; for my friend Mr. J. C. Shenstone, of Colchester, has informed me that he has found, in the High Woods, near that town, an umbellate form of the Primrose, although no Cowslips are known to grow within five miles, the species being apparently absent from the Tendring Hundred of Essex.

Probably little doubt would ever have been entertained as to the hybrid nature of the Common Oxlip had it not been for the fact that it bears a fairly-close general resemblance to a plant —an undoubtedly-good species—which is common and widely distributed on the Continent and is also met with in the Eastern Counties of England, namely, the *Primula elatior* of Jacquin. For more than half a century, it was generally assumed, both in Britain and on the Continent, that the "Oxlip" (*P. acaulis* × *veris*) found more or less commonly throughout the former was

identical with the "Oxlip" (*P. elatior*) common on the Continent, and much confusion arose therefrom. The matter was not cleared up until it was recognized that *both* forms occurred in Britain, the last-named being, however, confined to a comparatively limited area. It is not unfrequently stated * that the "Common (Hybrid) Oxlip" of Britain does not occur upon the Continent; but this is not correct. Not only do Grenier and Godron †, and Kerner ‡, mention it, but I have myself seen specimens. Probably, however, it is true that, proportionately to the abundance of the two parent species, it is less common there than with us; for the two parent species are not only less mixed there than here (the Primrose being mainly a plant of the valleys and lowlands, while the Cowslip chiefly flourishes in mountain pastures), but the distribution of the two over Europe, though wide, is by no means the same. Doubtless the mixing of the two in Britain (and the consequent greater frequence of hybrids) is due, as often stated, to the peculiarly-mixed nature of our insular climate. At all events, the "Hybrid Oxlip" and the "True Oxlip," though they have a general resemblance one to the other, are totally distinct, and no careful botanist with the two before him in a fresh state could possibly confuse them, even at a glance.

III. Primula elatior.

I come now to speak of the "True," "Bardfield," or "Jacquin's" Oxlip (*P. elatior*, Jacq.).

There can, I think, be little or no doubt that this is the plant for which Linnæus intended his name "*Primula veris* [var.] *elatior*,"§ and which he describes as having the limb of the corolla flat ("*limbo corollarum plano*"); but this is not the generally-received opinion. Linnæus's own herbarium (which I have examined) throws no light upon the matter. Certainly, however, it is the *Primula elatior* of Jacquin (1778) ‖ and of all later

* *E.g.*, 'English Botany,' ed. III. vol. vii. (1867) p. 137.

† 'Flore de France,' vol. ii. (1850), p. 448.

‡ Oesterr. bot. Zeit., 1875, p. 77.

§ 'Species Plantarum,' ed. II. (1764), p. 204.

‖ 'Miscellanea Austriaca,' vol. i. (1778), p. 158.

Continental (but not all British) writers. Probably the earliest post-Linnean figure of the plant is that in Oeder's 'Flora Danica.' *

Primula elatior, Jacq., has a very wide, though somewhat capricious, distribution upon the Continent. It occurs in the Pyrenees, and extends thence westward over most of Central and Northern Europe to the confines of Siberia. In the Mediterranean region, it is generally absent. It flourishes chiefly in wet alpine meadows and in woods.

The history of our knowledge of the plant in Britain is somewhat peculiar. There can be very little doubt that it was (in part, at least) the "Great Cowslips or Oxlips" (*Primula veris elatior pallido flore*) of Ray (1660)†. Ray could hardly be otherwise than familiar with the plant, owing to his long residence at Cambridge (near which place it grows) and to the fact that every time he journeyed from that place to his birthplace and home at Black Notley, in Essex, he must have passed through the very heart of the region occupied by the plant in Britain. Whether, however, he distinguished it from the Common (Hybrid) Oxlip is open to question. In the eighth volume of the first edition of 'English Botany,' published in 1799 (p. 513), the true *Primula elatior* of Jacquin (1778) was figured—not, it is true, with absolute accuracy, but still quite unmistakably‡. This is all the more remarkable because, at that time and for half a century later, the Common (Hybrid) Oxlip was, in Britain, generally confused with, and regarded as, Jacquin's plant; indeed, from what the author of 'English Botany' says, it is clear that he himself did not distinguish between the two. That he figured the true species, and not the better-known hybrid form generally mistaken for it, was, therefore, certainly due to a fortunate

* 'Flora Danica,' vol. iii. (1770), pl. 334. The descriptions of Plates 333 and 334 (the Cowslip and the Oxlip respectively) appear to have been transposed through a printer's error.

† 'Catalogus Plantarum circa Cantabrigiam nascentium,' p. 71.

‡ This figure (which has appeared in all later editions of the work, including that now current) was drawn from a plant supplied by "the Rev. Mr. Hemsted," but where that gentleman resided I know not. Dr. Blomfield believed (see 'Phytologist,' vol. iii. p. 695) that he lived somewhere in Essex. The figure errs in representing the stalk too thick, the calyx of an incorrect shape and of a wrong length in proportion to the pedicel, while the arrangement of the flowers in the umbel is not altogether true to nature.

accident, rather than to any care in discrimination on his part. That there were, nevertheless, at this time, or shortly after, British botanists who were familiar with (though they did not recognize) the true Oxlip of Jacquin in its English habitat is certain. Henslow and other Cambridge botanists could not be otherwise than familiar with it; and, in Henslow's Herbarium of Cambridgeshire plants, now in the University Museum, there are genuine specimens of *P. elatior*, Jacq., from Bartlow on April 8th, 1826. This fact, however, does not prove that Henslow or others at that time discriminated between the True and the Common (Hybrid) Oxlip. Probably, indeed, they did not. The first to recognize the difference between them appears to have been Edward Forbes, who, as early as 1838, pointed out* that the "*Primula elatior*" of British botanists was certainly not the same plant as the *Primula elatior* of Jacquin, which latter, he believed, did not occur in England; but the confusion between the two was, at that time, so great that no one seems to have taken any notice of what he wrote. However, a year or two later, a good deal of interest came to be taken in the nature of the Common (Hybrid) Oxlip of Britain, and in the question whether it was a hybrid or not, and what bearing its existence had upon the question as to the specific distinctness or otherwise of the Primrose and the Cowslip. These points were warmly discussed in the pages of the 'Phytologist' and the 'Gardeners' Chronicle' during the years 1841–46. H. C. Watson†, Prof. J. S. Henslow‡, R. S. Hill (of Teddington)§, W. Marshall‖, Dr. W. A. Blomfield¶, J. B. Whiting**, "S."††, J. P. Brown (of Thun)‡‡, and others, all published their views upon the matter. The two first-named printed in detail the results of experiments which they thought threw light upon the matter; but the fertilization of flowers (and especially of

* Ann. Nat. Hist. vol. iii. (1839), p. 122.

† 'Phytologist,' vol. i. pp. 9, 232, & 1002; vol. ii. pp. 217, 285, 313, & 852; and vol. iii. pp. 43 & 45.

‡ *Op. cit.* vol. i. p. 191; and vol. iii. p. 651.

§ *Op. cit.* vol. i. p. 188.

‖ *Op. cit.* vol. ii. p. 284.

¶ *Op. cit.* vol. iii. pp. 690–696.

** 'Gardeners' Chronicle,' October 9th, 1841.

†† *Op. cit.* March 12th, 1842.

‡‡ 'Phytologist,' vol. i. p. 192.

dimorphic heterostyled flowers) was so little understood at the time that their conclusions are of very small value.

Very early in this discussion, on February 10th, 1842, the Rev. J. E. Leefe was led to call the attention of the Botanical Society of Edinburgh to the Oxlips found in the woods round Saffron Walden *; but he failed to detect the fact that these were really the true *P. elatior* of Jacquin, which had not then been recognized in Britain. It was left for a man better known as an entomologist and an ornithologist (namely, the late Henry Doubleday, of Epping) to point out to English botanists the occurrence in this country of the true *Primula elatior* of Jacquin; and to him belongs the credit for removing the confusion which had so long existed. Having been accustomed to visit his first-cousin, the late Richard Smith, at Great Bardfield, Essex, he had observed that the Oxlips he found growing abundantly around that place were quite distinct from those he was accustomed to meet with now and then around his home at Epping and elsewhere; and, on April 18th, 1842, having read the discussion then raging (especially, it appears, the remarks of "S."), he communicated to the Botanical Society of London, through his brother Edward (then an officer of the British Museum), his belief that the so-called "*P. elatior*" of British botanists was merely a hybrid between the Primrose and the Cowslip; that it was quite distinct from the *P. elatior* of Jacquin; that the latter was a good species; and that the Oxlips he had observed at Great Bardfield were of that species †. Two days later, he expressed the same views in a letter to his friend the late Edward Newman (then editor of the 'Phytologist'), to whom he sent specimens ‡. The correctness of his view that the Bardfield plant was distinct from the *Primula elatior* of all previous British writers, but identical with the *Primula elatior* of Jacquin and other Continental writers, was quickly demonstrated by the published opinions of H. C. Watson§, Edward Forster‖, G. S. Gibson¶,

* See 'Phytologist,' vol. i. p. 191, and Ann. Nat. Hist. vol. ix. p. 153. He says, however, that these Oxlips do not agree with the figure in 'English Botany,' which is correct in fact (see p. 178, note), but incorrect if he meant (as appears to be the case) that the figure represented another species.

† Ann. Nat. Hist. vol. ix. p. 515.

‡ 'Phytologist,' vol. i. p. 204.

§ *Op. cit.* vol. i. pp. 232 & 1002; vol. ii. p. 527.

‖ *Op. cit.* vol. i. p. 974.

¶ *Op. cit.* vol. i. p. 996.

Edward Newman*, Prof. Babington†, Thomas Bentall‡, and other English botanists of the day §. Thus, at last, the fact was recognized that the true *Primula elatior* of Jacquin and the Continental botanists occurred in Britain, as well as the better-known (because more widely distributed) Common (Hybrid) Oxlip.

Since that time, the distinction between the "True" and the "Spurious" (Hybrid) Oxlips has been more or less clearly recognized; but, even now, there appear to be English botanists of high authority who are still unfamiliar with, or doubtful of, their distinctness; whilst the various interesting points in the natural history of the true species in Britain, to which I shall hereafter call attention, are practically unknown. In the last (fifth) edition (1887) of Bentham's 'Handbook of the British Flora,' ed. Hooker (p. 290), it is stated that "the distinctness is scarcely proved satisfactorily,"—a statement which could not possibly have been made had those authors been personally familiar with the two forms in question.

It is no longer possible seriously to discuss the question whether *P. elatior* is a hybrid or not. The readiness with which it enters (as stated hereafter) into hybrid unions with the Primrose shows, undoubtedly, that the two are nearly related; but the word "species" (though admittedly incapable of exact definition) has no meaning whatever if a plant which extends over a very large part of both Europe and Asia, which grows in immense abundance wherever it is found, and (except when exposed to the hybridizing influence of its near allies) preserves its characteristic features unaltered—can be said to be a hybrid. And *P. elatior* does all this.

* 'Phytologist,' vol. i. pp. 204, 975, & 997.

† *Op. cit.* vol. i. p. 1018.

‡ *Op. cit.* vol. ii. p. 515.

§ On this account, *P. elatior*, Jacq., is still commonly called in Britain "the Bardfield Oxlip;" but this name is somewhat inappropriate, inasmuch as the plant is in no respect peculiar to Bardfield, which place lies, indeed, almost on the margin of the area occupied by the plant in Britain.

IV. *Recorded Localities for* P. ELATIOR *in Britain.*

As regards the distribution in Britain of the True Oxlip, *Primula elatior* of Jacquin, it may, in the first place, be observed that a plant with such an extremely wide Euro-Asian distribution might naturally be expected to occur (like most plants of equally-wide Continental distribution) almost all over Britain. The expectation, however, is not, in this case, realized; for the distribution of the plant is, with us, greatly restricted, and in a remarkable manner for which it is not very easy to account. Before proceeding to define the area occupied by the plant in Britain, it is necessary to observe that the information given on this point in our English Floras is quite misleading.

In 'English Botany' it is stated * that the Oxlip occurs, "In woods and meadows on clay soil; local; plentiful in some parts of Essex, Suffolk, and Cambridge."

Babington says†, "Clayey woods and meadows in the Eastern Counties."

Bentham says‡, "In some of the Eastern Counties of England."

Hooker says§, "Copses and meadows in Bedford, Suffolk, Cambridge, and Essex."

Hayward gives ‖, "Copses; East of England."

Turning next to the Floras of those English counties in which the plant occurs, we find similarly misleading information given therein.

Gibson says ¶ of its distribution in Essex: "Woods and meadows; common in some parts of Essex."

Hind says ** of Suffolk: "In woods; rarely in meadows."

Babington says †† of Cambridgeshire: "Woods on clay."

The occurrence of the Oxlip in many other counties is recorded in the Floras of those counties or in other Local Lists of Plants; but, as it is, I believe, certain that in all cases the Common Hybrid Oxlip has been mistaken for the "True" species, the information as to distribution given therein may be disregarded.

The foregoing statements as to the distribution of the plant

* Ed. III. vol. vii. (1867), p. 135.

† Man. of Brit. Bot. 8th ed. (1881), p. 290.

‡ Handb. Brit. Flora, 5th ed. (1887), p. 290.

§ 'Student's Flora,' 3rd ed. (1884), p. 261.

‖ 'Botanist's Pocket-book' (1889), p. 114.

¶ 'Flora of Essex' (1862), p. 248.

** 'Flora of Suffolk' (1889), p. 282.

†† 'Flora of Cambridgeshire' (1860), p. 188.

in Britain, though not incorrect so far as they go, are quite misleading. They state but half the truth, which is always almost as deceptive and unsatisfactory as an actual misstatement. Any one reading them would naturally infer that the True Oxlip (*Primula elatior*, Jacq.) occurs more or less casually and sporadically, and in no remarkable abundance, at various spots throughout the Eastern Counties of England.

The real facts of the case, as shown in the following sections, are that the species in question

(*a*) occupies *a definite and very-sharply-defined area*; that,

(*b*) within that area, it everywhere grows—at least, in all places suited to its needs—*in immense abundance.* Not less remarkable is the fact that,

(*c*) while the *Primrose* grows abundantly all round the area occupied by the Oxlip, *it is entirely absent from that area*; but that,

(*d*) along the mutual boundary-line which separates the two species, they *produce hybrid forms in great abundance.* On the other hand,

(*e*) the *Cowslip* grows abundantly, not only all around but *throughout the area occupied by the Oxlip*; but

(*f*) the two *very rarely hybridize.*

I will proceed to discuss these six points in their due order.

V. *The Area occupied by the Oxlip in Britain.*

I have personally, and with considerable precision, traced the boundaries of this "Area," which lies mainly in the adjacent portions of the counties of Essex, Suffolk, and Cambridge, but extends also just beyond the county boundaries of Hertfordshire and Huntingdonshire, while there is at least one outlying locality in the northern part of Suffolk and another in the southern part of Norfolk. Although divided into two "Districts" (as I may call them)—an Eastern and a Western—and although there are at least two outlying localities, we may, I think (for reasons to be stated hereafter), speak of the Oxlip as occupying a single Area.

Taking, first, the larger, or Eastern, District, and starting from the point of its most north-westerly extension (a mile or so south from Higham, in Suffolk), the boundary-line proceeds southwestward to Dalham and then, after entering Cambridgeshire, more or less westerly, through Wood-Ditton, Stetchworth, and Dullingham, to Westley-Waterless and Brinkley, where it turns

almost due south, continuing through Weston-Colville, West Wratting, Balsham, Horseheath, and Bartlow to Saffron Walden in Essex. Thence, still proceeding southerly, but a trifle more westerly, the boundary-line passes through Newport, Quendon, Rickling, and Farnham, to Stanstead Montfitchet. All these places are in Essex; but, between the two last-named, a very small projecting portion of Hertfordshire is included. The boundary-line next proceeds in a south-easterly direction, passing through Essex, almost to Hatfield Broad-Oak, taking in a portion of Hatfield Forest and the Park Wood, near Barrington Hall, at which latter point the Oxlip-Area reaches its most southerly extension. From here, the boundary runs north-eastward to Great Easton, whence it continues in an almost due easterly direction for about fourteen miles, passing just south of Lindsell and Great and Little Saling and through Panfield, to a point about two miles almost directly south from Halstead. From this point, the boundary-line turns sharply back, following a semicircular course (which excludes Gosfield, Sible Hedingham, Castle Hedingham, and Gestingthorpe) to Belchamp Walter. There it once more turns sharply back, passing almost straight, and in a due westerly direction, for about eight miles, and excluding Belchamp Otten, Ashen, and Birdbrook, near which last-named place it executes another semicircular curve, in the course of which it re-enters Suffolk near Haverhill. From near Kedington, the boundary-line proceeds through Poslingford, Shimpling, and Lavenham, to near Bildeston, thus passing almost straight (though with one slight projection to the south of Lavenham) in an almost due easterly direction for about seventeen miles. The Oxlip-Area extends some four or five miles still farther East, from Bildeston to near Willisham, but it would not, I believe, be correct to say that the boundary-line of that Area does so; for I have reasons for thinking that the boundary-line (which I have not traced precisely at this point) here includes a projecting spur of the Oxlip-Area, having at its base a line drawn between the two places named and extending in a south-easterly direction across the country lying north-east from Hadleigh. From Willisham (near which place the Eastern District reaches its most easterly extension), the boundary-line continues in a more or less north-westerly direction through Barking and Great and Little Finborough, to near Harleston, where it turns almost

directly west, continuing thus for about eight miles, through Drinkstone and Hessett, almost to Rushbrook, at which point occurs a very sharp and deep indentation, extending into the heart of the Eastern District for about four miles, and excluding from that district Bradfield St. Clare, Little Welnetham, Great Welnetham, and Nowton—in fact, the greater part of the upper portion of the valley of the river Lark. On the western side of this indentation, the boundary-line, commencing at Westley, a mile or so west from Bury St. Edmund's, proceeds almost due west for about five miles, passing slightly to the north of Little Saxham and through Barrow to Higham, whence we started. Between Westley and Barrow, however, I have not actually defined the boundary, and there may exist a small (though certainly not a great) extension northward in the direction of Risby, Hengrave, and the Fornhams.

The District thus defined (which extends, as stated, into four counties) covers an area of about 475 square miles.

Turning, next, to the smaller, or "Eastern," District of the Oxlip-Area, we find that, commencing on the north at or near Elsworth, in Cambridgeshire, the boundary-line runs more or less south-westward, through, or near to, Papworth-Everard, Eltisley, and Great Gransden, after which, passing for a short distance through a projecting portion of Huntingdonshire, it re-enters Cambridgeshire near Gamlingay, and, turning almost due east-ward, it so continues for about six miles, through St. George's Hatley to near Eversden. Thence, turning northward, the boundary-line runs through, or near to, Kingston and Hardwick to Boxworth, which is near to Elsworth, whence we started.

The Second District thus defined (which extends, as stated, into two counties) covers an area of about 45 square miles.

The boundary-lines of the two "Districts" of the "Oxlip-Area" as thus laid down (together some 175 miles in length) have been, as stated, wholly traced by myself personally, mile by mile, at no inconsiderable expenditure of time and trouble. I do not, of course, guarantee that their positions are *absolutely and exactly accurate*; but I believe them to be so as nearly as any one man can ascertain them. They are, at any rate, sufficiently accurate for practical purposes. Although in tracing them I have been in the first instance guided to some extent by the records of others, I have in no single case accepted any of

these records without personal corroboration, because I have found by experience that all such records—even those by first-rate botanists—are wholly unreliable, owing to the Common (Hybrid) Oxlip (*Primula acaulis* × *veris*) having, in the case of most of them, been taken for the True Oxlip (*P. elatior*, Jacq.). Thus Gibson, in his 'Flora of Essex' (p. 248), records the latter as "frequent" near Broomfield, the parish in which I reside, and in which I can assert positively that it does not occur. The same may be said of the adjacent parish of Springfield, in which Gibson also records its occurrence. Most of Gibson's other localities are correct; as, also, are most of those given in Babington's 'Flora of Cambridgeshire.' A majority of the localities given in Hind's 'Flora of Suffolk,' and one of the two given in the "Supplement" to Trimmer's 'Flora of Norfolk' are, I believe (as more fully stated hereafter) incorrect; as, also, of course, are those given for the plant in the Floras of many other Counties in which it certainly does not occur.

This brings me to the subject of the outlying localities for *Primula elatior* already alluded to. Hind, in his 'Flora of Suffolk,' records, mainly on the authority of others, the occurrence of the plant at some eight localities in East Suffolk, as follows:—

Bungay (Mr. D. Stock, of Bungay).
Burgate Wood (Hind).
Dennington (N. F. Hele).
Woolverstone (Hind).
Aldeburgh (N. F. Hele).
Great Bealings (Rev. E. J. Moor).
Ashbocking (Miss F. C. Stanford).
Hemingstone (Rev. T. Brown).

Every one of these records relates, I believe, to the Hybrid Oxlip; and, in this view, local botanists whom I have consulted agree with me.

Hind also records a number of localities which lie within the Oxlip-Area as defined by me, and which, therefore, I accept.

Finally, he records *Primula elatior* from some nine localities lying around, and within a mile or two of, Honington, where he himself resided. They and the authorities on which he records them are as follows:—

Fakenham Wood (Hind).

Sapiston (Hind).
Troston (Hind).
Ixworth Thorpe (Hind).
Barton (Lady Blake's Herbarium in Ipswich Mus.).
Fornham (E. Skepper?).
Walsham (Mrs. Dunlap's Herbarium).
Pakenham (Mrs. Casborne's Herbarium).
Tinworth Wood (Rev. J. D. Gray).

As to these records, I am in doubt. I have visited most of the places named without being able to detect the plant; and, as the parcel containing the genus *Primula* appears to be missing from Hind's Herbarium in the Ipswich Museum, it is impossible to obtain definite evidence upon the subject by reference to his specimens. If the records in question, or any of them, really relate to the True Oxlip of Jacquin, the existence of numerous detached and outlying localities is established, for the district is certainly what I am accustomed to speak of as "Primrose-Country." It may be that such outlying localities do occur and would be found if greater search than I was able to undertake were made; for, in a wood known as "The Thicks," at Great Livermere (which is within the district covered by these records), I was surprised to observe a small patch of plants which were unquestionably of the True species, though Primroses were growing all around. This locality lies five miles and a half north from the nearest point of the boundary of the Oxlip-Area*.

A second outlying locality for the True Oxlip is to be found in Norfolk, namely, on a boggy spot on the side of the Mudholes Hill at Dickleburgh, which is at a distance of about 16 miles north-east by north from the nearest point of the true Oxlip-Area. Undoubted plants from this locality have been sent to me in a fresh state by Miss A. R. Smith, of Dickleburgh, who discovered the plant there some years ago, and who says that it has been known to grow there for at least half a century. The plants, which have always been small, appear to be decreasing in size†. The Rev. Kirby Trimmer, in the 'Supplement to the

* Mr. Henry Miller, of Ipswich, informs me that years ago he observed the plant growing in abundance in wet meadows beside the river Lark at Fornham, which is another locality in the same district; but I have seen no specimens.

† This locality was first recorded by the Rev. F. W. Galpin in his 'Flowering Plants . . . of Harleston' (London & Harleston, 1888), p. 85 See also H. D. Geldart in Trans. Norf. & Norw. Nat. Soc. vol. iv. (1884–89), pp. 579 & 722.

Flora of Norfolk' (1889?, p. 47), gives "Flordon, May 1870," as another locality for the True Oxlip; but, as my friend Mr. Edward Corder, of Norwich, has carefully searched this parish and found no trace of it, I conclude that Trimmer's record relates to the Common (Hybrid) Oxlip.

The existence of at least two outlying localities for *P. elatior* (which I definitely established only this year) greatly surprised me, as my previous observations, extending over many years, had not led me to expect anything of the kind. Probably they (and any others like them which may exist) may be regarded (for reasons to be given hereafter) as evidence of a former greater extension of the Oxlip-Area. Along the southern boundary-line of the Oxlip-Area, I know of no outlying localities for the species, and I believe that none such exist.

I am, of course, not in a position to assert that the True Oxlip does *not* occur in any other part of Britain; but I have no reason to suppose that it does. Its name appears, it is true, in scores of Local Lists of Plants covering the greater part of Britain; but I believe (as already stated) that all these records relate to the Hybrid Oxlip (*P. acaulis* × *veris*). Years ago, the Rev. W. W. Newbould informed me, on the authority of Professor W. Hillhouse, that it grew at Clapham and Marston, in Bedfordshire; but dried specimens and information kindly supplied to me by the latter gentleman have caused me to doubt the truth of the statement.

It will be found that the two Districts forming the Oxlip-Area and the two outlying localities extend into seven of Watson's Botanical "Counties" (Nos. 19, 20, 25, 26, 27, 29, and 31), instead of the six in which the plant is said to occur in the last edition of the 'London Catalogue,' wherein Bedfordshire (which I have excluded) is admitted.

It may well be asked: What physical fact or facts govern the Distribution in Britain of *Primula elatior* and cause the Area occupied by it to be so comparatively limited and so very sharply defined and to assume such a remarkable configuration? An examination of any map will go some way towards providing an answer. It will be seen, in the first place, that the Area in question is, comparatively speaking, an elevated one—in fact a "height of land" or watershed from which rivers run down in all directions. It is, though limited in extent, as near an

approach to an elevated plateau as the Eastern Counties can boast. It will be observed, in the second place, that the Area covers only the upper portions of the valleys of the rivers which run out of it. The valleys of the Stort, Chelmer, Pant, Brett, Kennett, and Bourne all, as they leave the Oxlip-Area, produce more or less slight indentations in its margin; those of the Colne, the Stour, and the Lark produce remarkably sharp and deep indentations; while that of the Cam actually cuts the Area into two portions—the Eastern and Western Districts already mentioned. The latter is the only river that runs actually *through* the Oxlip-Area. These river-valleys are, evidently, to a large extent responsible for the extreme sinuosity of the outline of the Oxlip-Area. If the boundaries of the Oxlip-Area be laid down on an Ordnance Map, a third fact becomes apparent—namely, that those boundaries scarcely anywhere descend below the 200-feet contour-line, thereby, of course, avoiding all but the upper portions of the river-valleys, as already mentioned. The bulk of the Oxlip-Area appears to lie at an elevation of from 200 to 400 feet, with a mean elevation of about 300 feet, the highest point within it (that about Saffron Walden and West Wratting) reaching the higher figure in several places. It can hardly be supposed that so small an elevation as 200 feet can alone influence in any way the distribution of *Primula elatior* or any other plant. Probably, therefore, there exists some co-related fact which governs the distribution of *Primula elatior*; and this appears to be the case.

If the boundaries of the Oxlip-Area be laid down with care upon the Drift maps (Ordnance) of the Geological Survey, it will be seen that the Oxlip is most rigidly confined to the Boulder Clay, nowhere extending off it on to the Chalk, the Gault, the Greensand, the River and Glacial Gravels, or on to any of the other formations and deposits which abut upon the Boulder-clay area, except where these extend into the Boulder-clay area in very narrow strips or occur within it in patches of extremely small extent. Nevertheless, the Oxlip does not even approximately occupy the whole of the extensive Boulder-clay area of Eastern England; nor even does the boundary of the Oxlip-Area anywhere coincide with that of the Boulder-clay area, except along the north-western border, where the boundary-line of both coincides almost exactly with that of the Chalk.

In all other directions, the Boulder-clay area extends far beyond the Oxlip-Area—southward, south-eastward, eastward, north-eastward, and northward. On examination, it will be found that the portion of the Boulder-clay area which is covered by the Oxlip-Area is not only the *most elevated* portion but is also the *most solid* portion, being less broken up than any other by the narrow strips of gravel and loam which line the bottoms of the river-valleys. Very probably, at some past time, the Oxlip occupied the greater part, or the whole, of the extensive Boulder-clay area of Eastern England; and I shall hereafter give a reason which I think goes some way to account for the subsequent contraction of its Area.

It should be mentioned that both the outlying localities already mentioned (at Dickleburgh and Livermere) are situated on Boulder Clay.

All the places named are shown on the accompanying map.

VI. *Abundance of the Oxlip within its Area.*

Every one has, in spring-time, seen the woods (especially those recently cut down) literally "carpeted" with Primroses. Within the region I have defined and have designated the "Oxlip-Area," the True Oxlip grows, in all ancient woods, in at least equal (if not, as I am inclined to think, in still greater) abundance. In many parts of some of the woods within the Area, the plants could hardly grow more closely packed together than they do; whilst, during the period of flowering (which may be defined as from the last week in March to the end of April, varying somewhat according to the season), their flowers make the ground appear yellow when seen from a short distance. It is true that the relative abundance of the plant in different woods within the Oxlip-Area varies greatly; but it may be said, nevertheless, that, in England at any rate, it is a striking and characteristic feature of the plant that it grows habitually in immense abundance wherever it is found.

The Oxlip, in short, *occupies* the area in which it grows as completely as the Primrose does the whole of the surrounding region and, indeed, the whole of England. I am not sure whether there is any other undoubtedly-indigenous British plant which grows in such enormous abundance over an area so limited and so sharply defined.

The abundance of the Oxlip in any particular wood varies greatly, it is true, according to circumstances. In a wood which is fully grown-up, the plant neither grows nor flowers, as a rule, in any special abundance *. When a wood is cut down, however—as all woods are every ten or fifteen years—an extraordinary change takes place. The sudden access of light and heat stimulates every plant to grow and to flower to the utmost of its power. The plants become larger and the umbels finer and more numerous. Simultaneously, various aberrations or monstrosities (to be referred to hereafter) appear. The full effect of this "stimulation" (as I call it) is, I think, observable in the second spring after a wood has been cut down. At such a time, a wood within the Oxlip-Area presents very striking and beautiful sight, the ground appearing yellow all round. On one occasion, by counting the number of plants growing on a typical space measuring four yards square and the number of umbels those plants bore, I was able to estimate that each acre bore about 70,000 plants having between them 220,000 umbels—an estimate I have reason to believe was very much below the mark. After the second or third year, the effect of stimulation passes off, leaving the plants in a weak and exhausted condition. Gradually the increase of grass and weeds smothers and hides the Oxlip plants; but, as time goes on, the former are, in their turn, smothered by the growth of the wood itself, and then the abundance of the Oxlip again becomes apparent, though comparatively few flowers are, as a rule, produced until the time for cutting down of the wood again comes round. A similar effect is produced upon the Primrose by the cutting down of the woods in which it grows; but the effect is not, I think, so remarkable as in the case of the Oxlip.

It is natural that a plant so abundant and well known locally as the Oxlip should have, within the area occupied by it, various local names. The name "Oxlip" (though used by Ray †, as

* I have occasionally observed marked departures from this general rule, for which I am unable to account. For instance, I observed the Oxlip both growing and flowering in immense abundance in a wood *fully grown-up* at Brinkley, Cambridgeshire, on April 19th, 1897, and a few days later in two fully-grown woods between Barrow and Denham, Suffolk.

† 'Catalogus Plantarum circa Cantabrigiam nascentium' (Cambr., 1660), p. 71.

already stated, in the form of "Great Cowslips or Oxlips" over two hundred years ago) appears to be a botanist's name and is used little, if at all, by the country people. In the Essex portion of its Area, the Oxlip is generally known as the "Cowslip" or the "Paigle"—both of which names are, both locally and elsewhere, commonly applied to the Cowslip (*P. veris*). In Suffolk (so far as my experience goes), these names are restricted to the Cowslip, and the Oxlip is known as the "Five-fingers." In Cambridgeshire, so far as I know, it has no local name.

VII. *Absence of the Primrose from the Oxlip-Area.*

Perhaps no fact in connection with the distribution of *Primula elatior* in Britain is more remarkable than the extreme sharpness of the boundary-line of the area occupied by the plant. Were the entire country still covered by aboriginal woodland, it would, I believe, be possible everywhere to define, to a couple of hundred yards or less, the line dividing the Oxlip-Country from the surrounding Primrose-Country. Both species everywhere grow abundantly (except at one spot, to be mentioned hereafter) right up to their common dividing-line, which may often be crossed with surprising suddenness. At many places round the border of the Oxlip-Area, one may pass from a wood in which only (or mainly) Primroses grow to another quite close in which only (or mainly) Oxlips are found; while, in not a few places, the boundary-line may be seen obviously to run through even a comparatively-small wood (as, for instance, Parson's Grove, near Lavenham, and Hardwick Wood, Cambridge), Oxlips only being found at one end and Primroses at the other. Everywhere along the boundary-line of the Oxlip-Area, this sudden transition may be observed more or less distinctly, except along that portion near Westley-Waterless and Brinkley, in Cambridgeshire, where the Oxlip-margin abuts upon an elevated, open, chalk district unsuited to the needs of either species. Notwithstanding the immense abundance of the Primrose all round the Oxlip-Area, I have never detected a single plant growing within that Area, except on or close to the margin. Nor have I ever seen a single plant of the Oxlip growing outside the boundary-lines I have laid down, except at the two spots already described (see p. 187). In short, the Oxlip-Area could hardly be more sharply defined.

VIII. *Hybridization of the Primrose and the Oxlip along their dividing line.*

The extreme facility with which the Oxlip and Primrose enter into hybrid unions one with the other is highly remarkable. Naturally, as the two species come in contact only along their mutual dividing-line, it is only there that they hybridize; but all along that line the two species produce hybrids in very great abundance.

The readiness with which the two species hybridize is so great that, at places along the boundary-line, it is no uncommon thing to find a greater number of plants of hybrid origin than of pure-bred plants belonging to both the parent species put together. Usually, however, it will be found that one species occupies chiefly one portion of a wood, while the other species occupies another portion, and hybrid plants in greater or lesser abundance occupy a more or less intermediate position. Such is very markedly the case in Parson's Grove, a small wood already alluded to, near Lavenham, in Suffolk; but the same state of things is observable to an equal extent in so many other woods along the boundary-line that it is needless to particularize.

That the plants in question are really hybrids admits, I think, of no reasonable doubt. They have not, it is true, been conclusively proved to be so by means of actual experiment; but there exists, nevertheless, a good deal of circumstantial evidence of much the same nature (though less definite and conclusive) as that which has been proved reliable in the case of experimentally-established hybrids between the Primrose and the Cowslip. It is as follows:—

(*a*) That they are always more or less intermediate in form between the two reputed parents;

(*b*) That they occur everywhere along the common boundary-line at which the two reputed parents meet; and

(*c*) That they never occur (so far as my observation goes) either in the interior of the Oxlip-Area or away from it in the Primrose-Country.

Next to the great abundance of these hybrids, nothing in connection with them is more remarkable than the uniformity of character which they present. In spite of the fact that one of

the parents (the Primrose) habitually bears single flowers, and notwithstanding that, when that species enters into a hybrid union with another umbellate species (the Cowslip), the hybrids which result therefrom present almost every variation between the two, the hybrids which result from a union between the Primrose and the Oxlip are remarkably uniform in character, being *almost invariably umbellate.* Hybrid plants bearing single flowers are occasionally found, but they are uncommon and exceptional. This is certainly somewhat remarkable. It may, perhaps, be taken as evidence that the parent which bears umbellate flowers (the Oxlip) is the prepotent (and, therefore, probably the female) parent; but, on this point, it is very difficult to obtain any tangible evidence, as both plants grow habitually in very similar situations. This conclusion, however, does not accord with the conclusion already arrived at to the effect that, in the case of hybrids between the Primrose and Cowslip, the former is probably the prepotent and female parent.

In some other respects, the hybrids of the Primrose with the Oxlip differ from those with the Cowslip. All the hybrids are, of course, more or less intermediate in form between their respective parents; but, in the former case, the hybrids are fairly constant in character, while in the latter they are very variable. Again, they differ much in their abundance relatively to that of their parents. While hybrids between the Primrose and the Cowslip are, considering the circumstances, comparatively scarce, hybrids between the Primrose and the Oxlip are very abundant. The latter may be due not so much to any exceptional readiness on the part of the Primrose and the Oxlip to enter into hybrid unions, as to the fact that the flowering-times of these two species are much more nearly synchronous than is the case with those of the Primrose and the Cowslip. The Primrose habitually commences to flower before the Oxlip, but the latter flowers before the Primrose has passed its best. The flowering-time of the Oxlip, in fact, is approximately intermediate between those of the Primrose and the Cowslip.

Although, as already said, the character of this Hybrid is fairly constant, one may detect two prevalent type-forms. One, the commoner, though umbellate, has the umbel irregular and straggling, without the elegant droop and regular arrangement of the usual Oxlip umbels, while the individual flowers are of a

pale colour and are generally more like those of the Primrose than those of the Oxlip. The other, and far less common, form much more closely approaches the pure Oxlip, having often the characteristic shape of the umbel, while the individual flowers are mainly of the Oxlip character, but much larger than usual, sometimes even approaching those of the Primrose in size.

Kerner has called attention * to the occurrence of this hybrid (which he calls *Primula digenea*) on the Continent, where, it seems, it is not rare. He says:—"I have specimens from Montreux (Vaud); from Le Mont, near Lausanne, in Switzerland; from Thauer, near Hall, in the Tyrol; from Fusse des Kesselberges, near Lake Kochel, in the Bavarian Alps; from Gamming, in the Erlafthale; and from Purkersdorf, in the Forest of Vienna, in Lower Austria." Many other Continental writers allude to the occurrence of this hybrid. The *P. intricata* and *P. Thomasinii* of Grenier & Godron † are, I believe, both synonyms for it, instead of for *P. acaulis* × *veris*, which I believe to be their *P. variabilis*. The first writer to call attention to the occurrence of this hybrid in Britain was the late G. S. Gibson, of Saffron Walden ‡.

The occurrence of an abundance of hybrids between the Primrose and the Oxlip may, I think, be found to throw some light on the strangely-restricted distribution of the latter in Britain.

The Oxlip is, almost certainly, not extending its boundaries in this country. It seldom, if ever, extends to new plantations, even in the heart of its Area. I may cite the case of an oak-plantation in Suffolk, sixty-nine years old, to which the plant has not extended, though it is abundant in woods within a mile in almost (if not quite) every direction §. There can, of course, hardly be a doubt that the Oxlip-Area has, in the past, been largely restricted, artificially, by the removal of woodland; but there appears reason to think that it has been, and is still being,

* Oesterr. bot. Zeitsch. 1875, p. 79.

† 'Flore de France,' vol. ii. (1850), p. 449.

‡ 'Phytologist,' vol. i. (1844), p. 996.

§ I refer to Windsor Wood, Little Saxham, the acorns for which were planted (as an inscribed stone in the wood records) in 1828 and 1829. Many oak woods in the Eastern Counties were planted or replanted about this time, the supply of large oak timber suitable for shipbuilding having become greatly reduced owing to the heavy demand for such timber for the navy during the long French war.

also decreased by natural means. Ray, in 1660, recorded it* as growing "in Kingston and Madingley Woods, abundantly, and elsewhere [near Cambridge]." Though still abundant in the first-named wood, I can testify that it does not now occur in the latter, in which the Primrose grows.

The Primrose, unlike the Oxlip, is certainly an aggressive and extending species. It readily extends to new plantations, hedgerows, and railway embankments, as may be seen everywhere.

May it not be, therefore, that the modest and retiring Oxlip is, in this country at least, being gradually hybridized out of existence by the more aggressive Primrose—that the Oxlip once extended over the whole of the extensive Boulder-clay district of Eastern England, but that its area has been, and is being, gradually reduced by the Primrose advancing on all sides and even, to some extent, gaining access into its interior by means of the river-valleys—and that the half-vanquished Oxlip is now making a last, but obstinate, stand, entrenched (as it were) upon two of the highest, most impregnable, and most inaccessible portions of its once-extensive territory, its forces having been cut in two by the onslaught of the potent Primrose, while two small companies are also able still to hold their own, though separated from the main body? This seems at least probable in view of what I have stated.

I have sometimes been interested in observing the distance over which the hybridizing influence of one plant or the other may extend. The conclusion I have arrived at is that the two species are capable of producing hybrids one with the other when growing at a distance of from half-a-mile to a mile apart. I may cite the case of Borley Wood, a very large wood in Cambridgeshire, in which Primroses are very abundant. Among them I found a fair number of plants which were obviously hybrids with the Oxlip; but, though I made a long search, I could see no trace of any pure Oxlip plants, though there may have been such. On entering Balsham Wood, another large wood lying from half to three-quarters of a mile further north, I found an abundance of Oxlips, together with a fair number of Primroses and hybrids between the two. Again, in a wood at Stanstead, in Suffolk, I found an obvious hybrid growing among Primroses when I had reason to believe that there were no Oxlips

* 'Catalogus Plantarum circa Cantabrigiam nascentium' (Cambr., 1660), p. 71.

growing nearer than Boxted, at least a mile away. I think, therefore, we are entitled to assume that, in these and similar cases which I have observed, the hybridizing influence has extended from one wood to the other. At not a few places around the boundary-line, I have discovered hybrid plants where one or other of the parent plants appeared at first to be absent; but, in all cases, further search or enquiry established the fact that plants belonging to the apparently-absent species grew within half a mile or so. No one has yet been able satisfactorily to show what species of insect or insects mainly fertilize either the Primrose or the Oxlip. I have elsewhere* discussed this question to a slight extent. The Primrose can hardly be fertilized mainly by bees, as it flowers at a very early period of the year when there are few bees abroad. Still it is certain that bees do visit both the Primrose and the Oxlip (especially the latter, as its flowering-time is later); and it is not difficult to believe that bees might easily transport the pollen of either species a mile or even further.

IX. *The Cowslip abundant throughout the Oxlip-Area.*

As previously said, the Cowslip flourishes in normal abundance throughout and around the whole of the Area occupied by the Oxlip.

X. *Hybrids between the Oxlip and the Cowslip very rare.*

As the Oxlip and the Cowslip come in contact at all points throughout the Oxlip-Area, one might (judging from the behaviour of each when in contact with the Primrose) not unnaturally expect them to hybridize freely; but this they are known not to do. Such hybrids are, in fact, very rare. Only on three occasions during the last eighteen years have I found plants which I believed to be hybrids between the Oxlip and the Cowslip—once in Madghob's Wood, near Saffron Walden, on April 23rd, 1883; once on a hedge-bank near Wethersfield, Essex, on May 1st, 1883; and lastly in Long Wood, Horningsheath, Suffolk, on April 25th, 1897. Mr. Thomas Bentall, an Essex botanist, has declared† that, although he knew the hybrid between the Oxlip and the Primrose, he had never met with the form now under consideration; nor, I believe, has anyone else than myself seen

* Trans. Essex Field Club, vol. iii. (1884) pp. 195–198 & 206–207.

† 'Phytologist,' vol. ii. (1846) p. 515.

or recorded it in this country. In connection with this rare union, it may be borne in mind that not only are the flowering-times of the two parent species not synchronous (the Oxlip flowers being nearly over before those of the Cowslip are fully blown), but the two plants have very different habitats (the one being essentially a plant of the woodlands, the other of the open meadows).

It seems as if the Oxlip was able to withstand almost completely the seductive hybridizing influence of the Cowslip, to whose presence it is everywhere accustomed, but was unable to withstand the blandishments of the Primrose, to whose presence it is only locally accustomed.

Although (as in the case of the reputed hybrids between the Primrose and the Oxlip) I can advance no final and conclusive proof of the hybrid origin of these plants, there appears, nevertheless, not the slightest reason to doubt that they are hybrids. For :—

(*a*) In each case where I have found them, both the reputed parents have been growing in close proximity;

(*b*) I have never observed similar plants in places where either of the two reputed parents has been absent; and

(*c*) They are in character intermediate between the two reputed parents.

It must be admitted, however, that, in general, these hybrids approach more nearly to the form of the Cowslip than to that of the Oxlip, having the large inflated calyx, the saucer-shaped corolla-limb, and the bright yellow colour of the Cowslip; but the size of the flower, the colour of the eye-spot, and other smaller characters unmistakably suggest the Oxlip.

Moreover, Kerner has called attention* to the existence on the Continent of a similar hybrid (which he calls *Primula media*) between the two forms in question. His statement that, considering that the two parent species grow close together in the greatest abundance in many Alpine valleys, the occurrence of hybrids between them is surprisingly rare, agrees very well with my own observations as to the rarity of this hybrid in Britain. Kerner names a few Continental localities in which he has found it, but adds that its rarity is not confined to the valleys of the

* Oester. bot. Zeitsch. vol. xv. (1875) p. 80.

Alps. Several other Continental writers have also noted the occurrence of this hybrid.

It thus appears that each of our three South-British species of the genus *Primula* enters, with greater or less freedom, into hybrid unions with each of the other two, thus producing *six different forms*—three species and three hybrids. It is an extraordinary fact that, around the margin of the Oxlip-Area (but, of course, nowhere else), it is no unusual thing to find *five of these six forms growing in one wood*, while the sixth and last (the rare *P. elatior* × *veris*) may occasionally be met with. It is not, therefore, altogether surprising that confusion should have arisen in the minds of botanists as to the specific distinctness and the distribution in Britain of our British members of the genus. I assert, however, that no careful botanist who sees specimens in a fresh state need ever be in doubt as to which of the six forms discussed above he may have before him—except, perhaps, when *P. acaulis* × *elatior* and *P. acaulis* × *veris* are concerned, for these two forms sometimes approach one another somewhat closely. This cannot be said of specimens when in a dried state, and I defy anyone to distinguish with certainty between the various forms when in this condition; for the distinguishing characters, though fairly obvious, are undeniably slight, and are largely obliterated in the process of drying.

XI. *Variation of the Oxlip in Britain.*

That the plant known in Britain as *P. elatior* is identical with that which passes under the same name on the Continent (where I am familiar with it, having collected it in Switzerland) admits, I think, of no doubt. Yet there is one point in which the two differ remarkably. On the Continent the plant is known as inhabiting mainly wet Alpine pastures. In this country, on the other hand, it inhabits woods almost as exclusively. It certainly does, in this country, sometimes grow in the open in low boggy meadows beside streams; but the quantity so growing is infinitesimally small compared with that growing in woods. Nearly, if not quite, all the British localities in which the plant grows in the open are, I believe, situated close to the edge of the Oxlip-Area, and most of them that I have seen lie near the heads of the deep indentations in the margin of the Oxlip-Area caused by the river-valleys, especially that of the

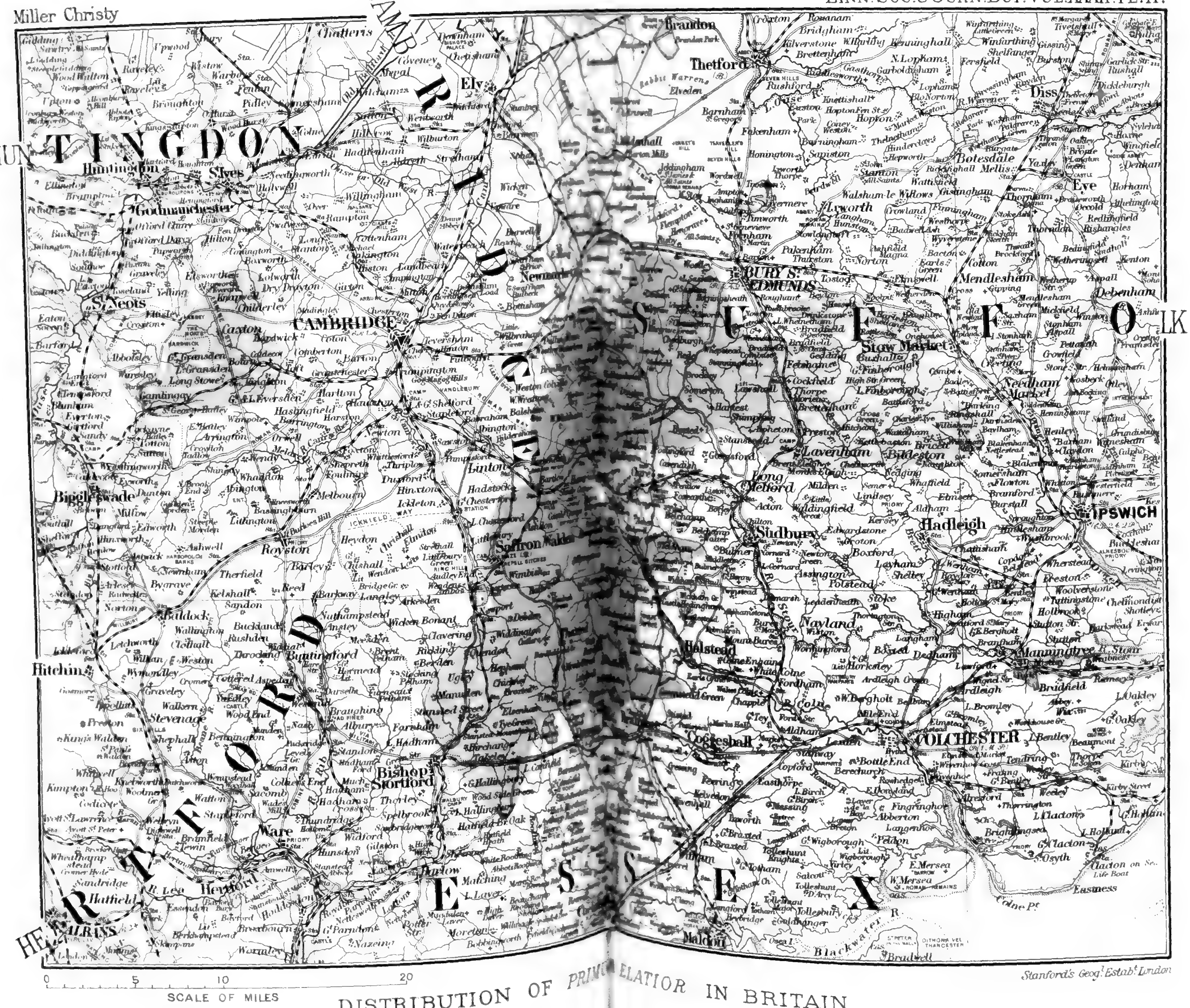
Stour. I have seen none of these localities in the heart of the Oxlip-Area—a fact for which I am unable to account.

There is another respect in which our English plant *may* differ from the Continental plant. Nearly all Continental botanical works describe *P. elatior* as scentless (*inodore*). If they are right in so doing (which I cannot help doubting) they establish a somewhat remarkable point of difference; for our English plant has a scent as strong as, if not stronger than, those of the Primrose and Cowslip, from both of which, though similar, it may be readily distinguished.

The Oxlip presents, in this country, so far as I know, only one departure from the type-form which may be classed as a variety: that is, a single-flowered, or acaulescent, form which appears not uncommonly very early in the flowering season—for the most part before the umbellate flowers have bloomed—and *then only*, so far as my observation goes. These flowers (though occasionally marked by certain aberrant developments to be mentioned shortly) are, in all essential respects, absolutely true Oxlip flowers and present no traces whatever of hybridism, while the plants producing them nearly always produce also, later in the season, flowers in normal umbels. Moreover, a plant which I have in cultivation has produced a full complement of seeds from one of these single flowers. Examination nearly always shows that these single flowers spring from one radical point. They may, therefore, I think, be said to grow in what may be called "sessile umbels"—umbels of which the peduncle has been suppressed; and the existence of these no doubt shows a certain tendency on the part of the plant to revert to an ancestral mode of inflorescence. If this form be deemed to be of varietal rank (which I do not myself consider it to be), I venture to propose for it the name var. *acaulis*.

The Oxlip in this country also not unfrequently assumes forms which may be regarded as monstrous rather than varietal. These, moreover, are almost invariably due to "stimulation," if not entirely so. The chief of these monstrosities or aberrations is that "fasciated" form in which a number of peduncles and umbels are (as it were) fused together side by side. In these fasciated specimens the peduncle, though no thicker than usual, is much broader, being more or less ribbon-like. I have frequently seen, growing under the influence of stimulation, fasciated peduncles bearing from forty or fifty up to one hundred flowers;

Miller Christy



DISTRIBUTION OF PRIMU ELATIOR IN BRITAIN.

while, on rarer occasions, I have seen this fasciation carried to an extraordinary extent, the flower-stalk, though no thicker than usual, being fully one inch in width and bearing more than 200 flowers massed together in the umbel at the top. Naturally, in such aberrant developments as these, the characteristic shape of the umbel is entirely lost, the flowers being so crowded together that they have to arrange themselves as best they can, while many never have a chance of opening. The Cowslip occasionally produces similarly fasciated umbels.

Often (though not always) associated with the fasciated flowers (and, like them, doubtless, due mainly to stimulation) is the form bearing irregular umbels, which sometimes include one or more leaves, and sometimes have several pedicels springing from the side of the peduncle below the umbel. Yet another not uncommon aberrant form which seems to be more or less connected with fasciation is that in which the flowers are synanthic, having a large number of calyx-teeth, many petals, twelve or more anthers, and a large flattened stigma.

Other abnormal floral developments, apparently not necessarily a result of stimulation, are (as already stated) associated with the single-flowered variety, being seldom, if ever, observable when the flowers grow in a normal umbel. The chief of these is that phyllodic form in which the calyx-teeth become developed into small, but perfect, leaves, from a quarter of an inch to an inch and a half in length. When the calyx-leaves (as we may call them) are developed to the greatest extent indicated, the inner floral organs generally remain small and aborted at the bottom of the abnormally-long calyx-tube. There are similar phyllodic forms of the Primrose and of the common Garden Polyanthus. Associated with this form (and therefore also with the single-flowered flowers), I have, on very rare occasions, observed "prolificated" flowers, having a corolla with anthers growing out of the centre of another flower. This sport is that known to horticulturists as the "hose-in-hose" variety when it occurs (as it does not uncommonly in cultivation) in connection with the Primrose and the Polyanthus.

EXPLANATION OF PLATE 11.

MAP showing the Distribution of *Primula elatior* in Britain (between pp. 184 & 185.)

On Buds and Stipules.—Parts III. & IV. By the Rt. Hon. Sir JOHN LUBBOCK, Bart., M.P., F.R.S., D.C.L., LL.D., F.L.S., &c.

[Read 18th March and 17th June, 1897.]

(PLATES 12–15.)

IN continuation of the observations which the Society has done me the honour to publish (Journ. Linn. Soc., Bot. vol. xxx. pp. 463–532), I submit now some further observations on the same subject.

The stipules, or small leaflets, which occur at the base of many leaves serve for various purposes. The most usual is to protect the leaves while in the bud—sometimes their own leaf, but as a rule the younger one. In some cases, however, they themselves perform the function of leaves, which indeed, in a few cases, they entirely replace. In others they serve to hold water; in some they develop into spines; in some into tendrils; in others they become glandular.

In the present paper many special cases are described, and where stipules are absent, the other arrangements for bud-protection are referred to.

Special attention is directed to the construction of the winter-buds of our commoner shrubs and trees.

These present curious differences—even in some cases between nearly allied species. In the Wayfaring Tree (*Viburnum Lantana*) the young leaves are uncovered, but protected by a dense covering of hairs. In *V. Opulus* the bud is protected by scales, representing modified leaves. In the Ash and Thorn the outer scales of the bud consist of expanded petioles. In the Willow the outer scales consist of leaves, in the Poplars of stipules. In the Oak and Beech each scale is a stipule; in the Elm and Spanish Chestnut each scale represents a pair of connate stipules.

The buds of the Oak and Beech are described in detail. In the Beech the outer scales of the bud consist of about 11 pairs of stipules. The twelfth is the first pair which has a leaf. The subsequent growth takes place between the leaves, but the part of the shoot between the stipules scarcely elongates at all. The consequence is that the seat of each winter-bud is indicated by a series of rings, which remain visible for many years and indicate each year's growth.

RULES FOR BORROWING BOOKS FROM THE LIBRARY.

As amended by the Council, 15th March, 1888.

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1. No more than Six volumes shall be lent to one person at the same time without the special leave of the Council or one of the Secretaries.

2. All books shall be returned before the expiration of Six weeks from the time of their being taken out, but if not required by any other Fellow, they may, *on application*, be kept for a further period of Six weeks.

3. All books lent shall be regularly entered by the Librarian in a book appropriated for that purpose.

4. No work forming part of Linnæus's own Library shall be lent out of the Library under any circumstances.

Note.—*Certain other works are included in this prohibition, such as costly illustrated works, and volumes belonging to sets which could not be replaced if lost.*

The Revised Rules concerning the publication of Papers have been already made known by circular, but, if required, additional copies may be had on application.

The present number of the Journal is the third issued under the new regulations, which are as follow :—

Papers read from November and before the middle of January are published on **1st April.**

Papers read after the middle of January and before the end of April are published on **1st July.**

Papers read in May and June are published on **1st November.**

NOTICE.

Vol. XXVI. is still in course of issue, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–219. (Complete.)

Vol. XXXII., Nos. 220–227. (Complete.)

Vol. XXXIII., Nos. 228 and 229 (the present Part).

Attention to this announcement is specially requested, to prevent application to the Librarian for unpublished Parts.

The new Catalogue of the Library is ready, and may be had on application. Price to Fellows, 5*s.*; to the Public, 10*s.*

All communications relating to the general business of the Society should be, as heretofore, addressed to the "Secretaries," but letters on library business only should be addressed to the "Librarian."

The first Meeting of the Session 1897–98 will be held on Thursday, November 4th, when the Chair will be taken at 8 p.m. precisely.

DECEMBER 2. *Price 4s.*

THE JOURNAL

OF

THE LINNEAN SOCIETY.

VOL. XXXIII. BOTANY. No. 230.

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1897.

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Members of the Selborne Society are reminded that their Subscriptions are due on the 1st of January, and are requested to forward them to the Local Hon. Secretary, but in the case of Members unattached to Branches, to the Secretary, Selborne Society, 20, Hanover Square, W.

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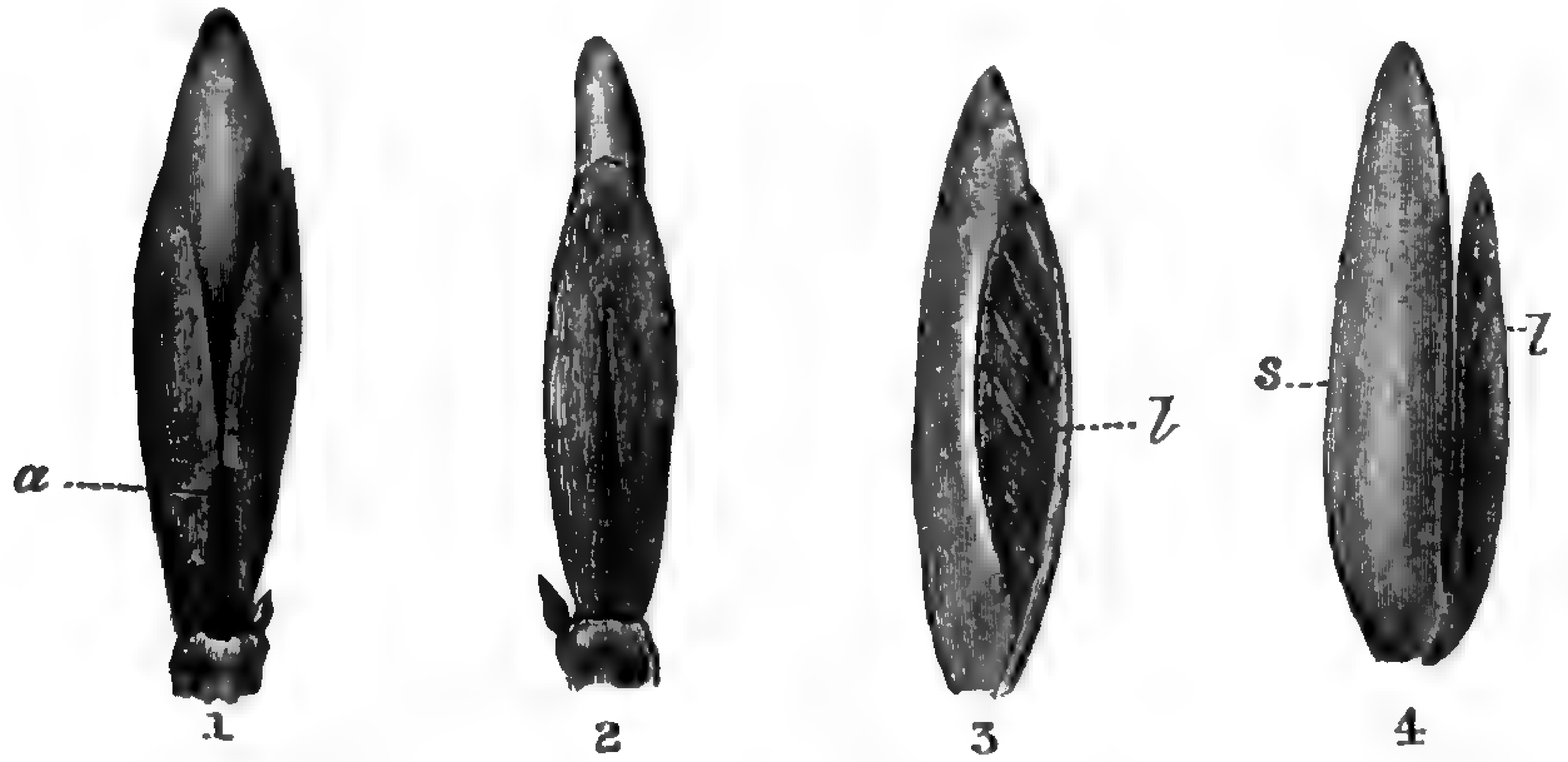
MAGNOLIACEÆ.

The interesting bud of *Liriodendron* has been already described. In *Magnolia* the bud is similar, but the leaf-stalk is short and the leaf upright.

Stipules connate, forming a covering all over the terminal bud.

Magnolia conspicua, Linn. (figs. 1–4).—When the leaf falls in autumn, the stipules detach themselves at the same time, or very soon after, thus exposing a small silky leaf and two stipules which enclose the bud. In our country this leaf seems always to perish. In *M. tripetala*, on the contrary, the stipules of the upper leaf are persistent and protect the bud. The stipules of *M. glauca* are covered with fine adpressed hairs. Within is a

Figs. 1, 2, 3, 4.



Magnolia conspicua, slightly enlarged.

conduplicate leaf (figs. 3 and 4, *l*): in fig. 4 the back only is seen. The stipules are about a third longer than their leaf. They are more woolly than the outer ones. The next pair are still woollier, and not much longer than their leaf. (See also Regel, Linnæa, 1843, p. 227.)

Michelia Champaca, Linn.—The stipules are linear, connate along both edges, and adnate to the petiole for more than half the length of the latter, but above this they are free from the petiole for more than half their own length. They are twisted in bud above the free portion, adnate to the raised line all round the stem, densely covered with pale brown hairs, kneed below the middle, splitting along both edges, and caducous.

The terminal bud is enveloped by the stipules, and, as it develops slowly like *Ficus elastica*, no more than one pair of stipules is exposed at a time.

The axillary buds are protected in the deep groove at the base of the petiole, and develop while the petiole is still erect.

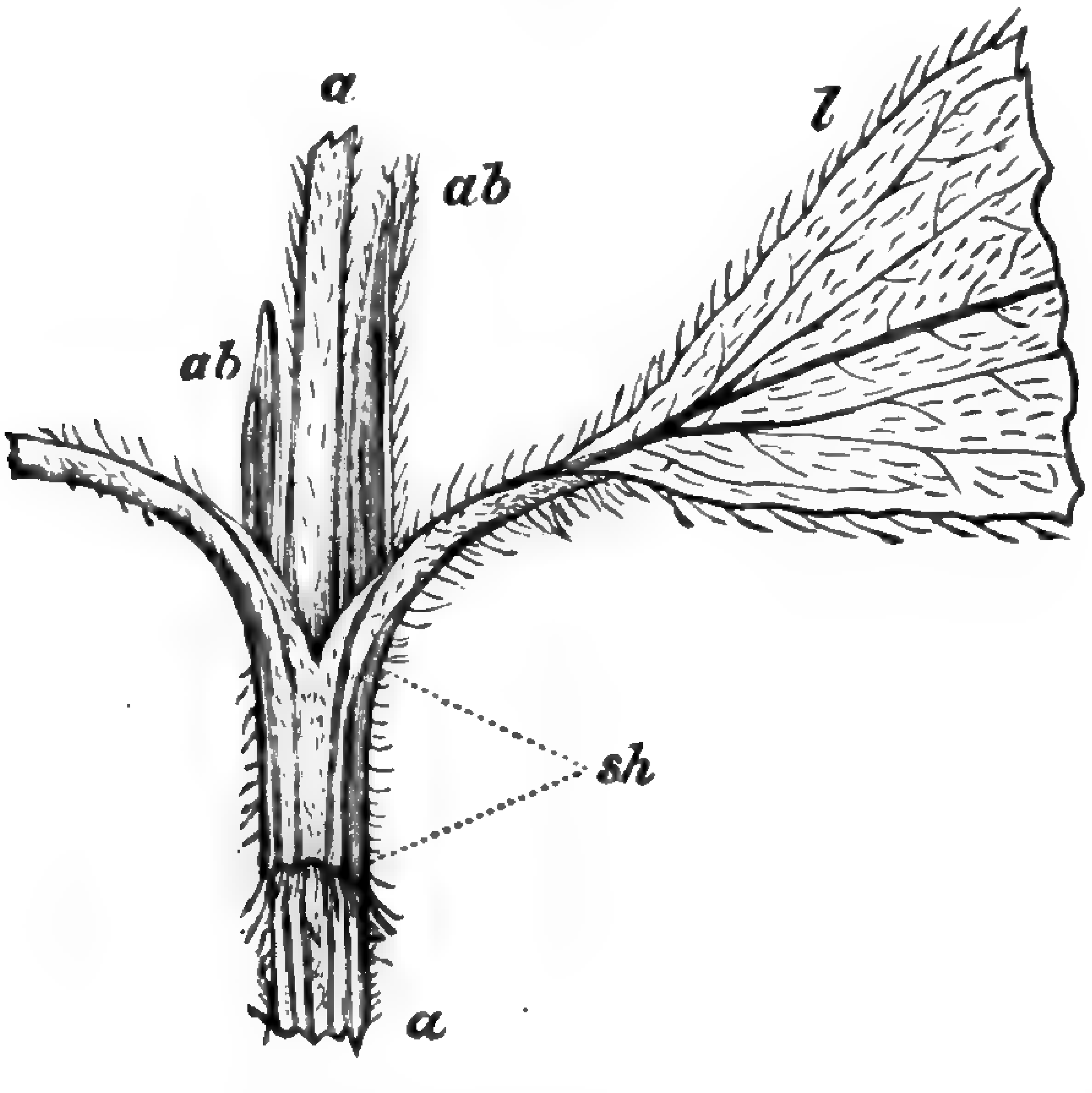
The leaf develops a long petiole while still covered by the stipules, and is folded much in the same way as that of *Magnolia glauca*.

CISTINEÆ.

I have already given several illustrations from this order.

In *Cistus vaginatus*, Ait. (fig. 5), the petioles are more sheathing than in any of the species previously noticed. The leaves are opposite, ovate, acuminate, 3-nerved in the lower half, petiolate, thinly villous but densely glandular-pubescent and viscid on both surfaces, as are the stems; petioles terete, ridged and furrowed, sheathing at the base; sheaths connate, forming a cylinder enclosing the stem, 1–1·8 cm. long.

Fig. 5.



Cistus vaginatus, nat. size.
a, *a*, axis; *l*, portion of leaf; *sh*, sheath formed by the dilated and connate bases of the petioles; *ab*, *ab*, axillary buds.

The terminal bud consists of several successive pairs of leaves, each pair protecting all the younger ones.

The oldest two leaves before expansion are rolled round one another, and have one edge of each inside one of the other of the pair. They attain a length of 4·5 cm., more or less according to their vigour, and about this stage leave the back of the next younger pair uncovered about the middle of the same, the sheath protecting the base. The leading bud is, therefore, well protected till the leaves attain a considerable size. The gum of the glandular hairs and the silky covering of the young leaves, as well

as the interior of the sheath, seem intended as a protection as much against drought and heat as against cold.

The lateral buds are similar, and entirely covered by the sheaths till they attain a large size.

TREMANDREÆ.

Platytheca gallioides, Steetz, is curiously like a *Galium*. The leaves are verticillate in decussating whorls of 8–11, linear, or acicular, revolute at the margin, sessile, thinly pubescent, slightly scabrid, articulate, persistent.

The terminal bud consists of numerous whorls of leaves graduated in size. The two outer have openings between them, but the third whorl is conical and close, the leaves fitting to one another pretty closely. There is, however, a subulate tuft of hairs between every two leaves.

Axillary buds few to each node, generally only one or two or none; when there are two, one is a flower-, the other a leaf-bud. They arise and partly elongate while still within the leaves, forming the terminal bud. The bases of the leaves are erect or ascending even after the lamina is horizontal, and they, together with the interpetiolar tufts of hairs, lend additional protection. The first whorl generally or often consists of eight leaves, and the first internode and the leaves themselves attain considerable length before expansion.

DIPTEROCARPEÆ.

Shorea robusta, Gærtn.—The stipules are linear-oblong in bud, lengthening with the growth of the bud, and becoming linear, falcate, concave over the bud, enclosing their own leaf; the greater part of the younger ones is furnished with an elevated ridge on the inner face, though not central, covered externally with short stellate hairs, caducous.

The terminal bud consists of small conduplicate leaves completely covered by one or two pairs of stipules; the latter are inserted on the stem and partly on the base of the petiole, so that they overlap their own leaf.

There are three buds, superposed. The middle one is the first to develop, and is already well advanced while still protected by the stipules of the terminal bud. A few of the lower leaves are reduced to their stipules, or, if the leaf is present, it is small, imperfect and caducous. Two pairs of stipules are necessary to

completely protect it. Later on a small bud arises above, but close to the base of the middle one, and another below the latter arises contemporaneously with the uppermost. Both the small buds seem to elongate during the following spring.

MALVACEÆ.

Pachira aquatica, Aubl.—Leaves alternate, petiolate, stipulate, digitate, with 7–11 oblanceolate, entire, glabrous leaflets arranged in a complete circle round the apex of the petiole; petiole terete, suddenly much thickened at the base.

Stipules ovate, acuminate, inserted upon the axis and partly lying in front of the petiole of their own leaf, erect, membranous at the edges, convolute in bud, caducous on the axillary, persistent on the resting terminal buds, but falling away on their expansion.

Terminal bud narrowly conical, sharply pointed, and covered by the convolute stipules. The leaves themselves are in the form of a narrow cone, pointed and somewhat compressed or flattened on one side. The leaflets are erect and conduplicate, with their edges in the centre of the cone, but as they unfold they become reflexed, umbrella-fashion, and gradually increase in size.

Axillary buds represented by a slightly elevated cushion with a darker spot in the centre; but they rarely, if ever, develop upon young plants: hence perhaps the stipules are caducous, being unnecessary, as is the case with *Sterculia fœtida*.

STERCULIACEÆ.

Sterculia fœtida, Linn.—Leaves alternate, petiolate, stipulate, digitate, glandular pubescent, but more particularly on the nerves, persistent; leaflets 7–11, oblong-lanceolate, narrowed to the base, sessile, arranged in a complete circle round the thickened apex of the petiole, with which they are articulated, but sessile. Petiole long, terete, greatly thickened at the base, where it is slightly thickened on the upper surface.

The persisting leaves are arranged in a dense tuft at the apex of the stem.

Stipules ovate-subulate, suddenly acuminate, inserted on the stem close to the thickened base of the petiole, caducous on the axillary, persistent on the terminal buds, but falling away on their expansion.

Terminal bud large, consisting of a dense, conical, imbricated mass of leaves and stipules; the latter equal the leaves in length

at this stage, and are practically fully developed. The whole lamina of the leaf is folded up in a small compact mass lying in front of the apex of the petiole, which at this stage constitutes the greater portion of the leaf. The relatively large stipules afford a considerable amount of protection, leaving only their petioles exposed, but the younger members of the latter are protected by the older.

Axillary buds seldom developed. A plant many years old, and about 1 m. 52 cm. high, had only one terminal and no lateral buds. This would doubtless account for the stipules being caducous all along the stem and also at the expansion of the terminal bud, there being nothing requiring protection after that stage of development.

Heritiera macrophylla, Wall.—Leaves alternate, large, very much crowded (as a rule) near the extremity of the shoots, petiolate, stipulate, and ovate-oblong or oblong, coriaceous, persistent, shining and thinly scaly on the upper surface and silvery beneath owing to a dense covering of peltate, circular scales which are dentate at the margin; petioles biconvex, thickened at the apex and base, articulate with the stem, densely covered with pale and deep brown scales.

Stipules 1·2–3·5 cm. long, subulate, much acuminate, ovate at the base, deeply concave on the inner face, densely scaly and caducous, excepting those covering the resting-bud, which are often more persistent than the leaves themselves. They also become hard and rigid.

Terminal bud covered by two pairs of stipules belonging to the last two developed leaves, which are generally smaller than those which lose their stipules in summer. Inside the two pairs mentioned are other stipules, which are longer than the leaves to which they belong while still in bud.

The axillary buds nestle between the thickened base of the petiole and the axis. Their scales are densely lepidote, like other parts of the plant. Comparatively few of them elongate into shoots, as the extreme shortness of the internodes and the great size of the leaves afford no space for their development. During periods of drought, or owing to other circumstances, the tree sheds the whole of its leaves, and at such times dormant axillary buds are encouraged to develop, so that the tree slowly becomes branched.

All the branches are thick, rigid, and of slow growth, producing

only a tuft of leaves annually or sometimes only at longer periods.

The stipules that persist and cover the resting terminal bud seem to dry up, partially at least, for they are more persistent than the leaves to which they belong. As a consequence, a series of stipules may often be found encircling the axis below the current crop or series of leaves, and these are dry, rigid, and gradually crumple or fall away in pieces till the old shoots become perfectly naked. The axillary buds long remain of a small size, and the scales covering them become hardened; hence, perhaps, the stipules in that case can be dispensed with.

Pterospermum acerifolium, Willd.—Leaves alternate, petiolate, stipulate, peltate, slightly and irregularly dentate, about 10-nerved, covered on both surfaces with stellate tomentum; petioles terete, gradually thickened to the base, densely stellate-tomentose.

Stipules unequally bipartite, inserted upon the stem close to the edges of the petiole, with subulate segments covered with a brown stellate tomentum, caducous, except those subtending the unexpanded leaves of the terminal bud.

Terminal bud in the growing stage pushed on one side by the thickened base of the youngest unfolding leaf, and appearing lateral. It consists of a mass of young leaves and stipules, open at the top owing to the peculiar vernation of the leaves, which are strongly involute at the margins, with short petioles. The outer ones are directed outwards between the stipules, so that the latter do not afford them any protection. They are, however, covered with a denser and darker brown stellate tomentum than the older leaves, and which affords them ample protection. The stipules are longer than the younger leaves and cover them.

Axillary buds small, nestling in the axils of the stout petioles and, like the terminal one, densely tomentose. They are seldom developed, so that the tree is sparingly branched.

Hermannia alnifolia, Linn.—Leaves alternate, distichous, petiolate, stipulate, suborbicular, dentate, alternately nerved, plicate, rugose, densely downy on both surfaces; petiole biconvex, not dilated at the base, about 1·25–1·5 mm. long, downy.

Stipules foliaceous, inserted upon the stem close to the edge of the petiole, triangular at the base, with a distinct midrib, revolute at the margin and drawn out into a long subulate point, downy, persistent.

Terminal bud, in the growing stage, large, consisting of numerous leaves arranged in a distichous manner, plicate along the veins and infolded at the sides, so that the two leaves cover all the younger members. The stipules are small at this stage, and only cover a small portion between two leaves.

Axillary buds arising at an early stage of growth and close to the growing axis. The first leaves are foliaceous, though small, and are protected not only by the stipules and the short petioles but also by the lamina of the leaf. They soon reach their full development. The stipules are of more service here than in the case of the terminal bud. This probably is the reason why the stipules are foliaceous and persistent around the axillary buds, whereas they are caducous in the case of *Sterculia fœtida*, *Pachira aquatica*, *Pterospermum acerifolium*, and *Heritiera macrophylla*.

TILIACEÆ.

Winter-bud of *Tilia vulgaris*, Hayne. (Pl. **12.** figs. 1–3.)

The pseudo-terminal (Pl. **12.** fig. 1) and lateral buds are very similar. They are generally lop-sided or tumid on one side owing to the thickening of the small outer scale, particularly along the midrib. The true apex of the shoot becomes disarticulated and falls off.

The scales of the winter-bud are arranged on alternate sides of the bud, the leaves being alternate and distichous. The outer scale overlaps the second at the base, but is little more than half its size, though ⅔ the length of the bud. The first two are coriaceous, glabrous, and not accompanied by a leaf, though serially continuous with those of the previous season; they are also obtusely and slightly carinate.

The next two are very much larger, more nearly equal in size, roundly cordate, showing an inclination to become petiolate owing to their being much wider than their insertion. They are glabrous, as long as the bud, rolled round three-fourths of it, the outer one covering the same extent of the inner, which is more membranous except at the tip. They are accompanied by a small, conduplicate, silky leaf.

The next pair are broadly elliptic, unequal, membranous, and more or less silky on both surfaces. The larger scale or stipule is always the outer of the pair. The second leaf is much larger than the first, densely silky, with unequal halves, the narrower one being always uppermost. The edges of the

leaf are always directed under the larger stipule; and it will be noted that the direction of the leaf and the larger of each pair of stipules are altered in each succeeding set. This is due to the alternate and distichous arrangement of the leaves.

The fourth pair are oblong-elliptic, covering three-fourths of the bud as in succeeding cases, and more silky than the previous pair on the outer face, but otherwise similar. The leaf is as long as the next younger pair of stipules, and lying in a convex manner over them.

The fifth pair are oblong, and the outer stipule covers less than half of its fellow. The sixth pair are more unequal and very much smaller. The seventh pair are oblong-lanceolate and very small, while the eighth pair are still smaller and very membranous.

The next younger leaf in each case lies beneath its own stipules, and in that position corresponds to the opening left uncovered by the previous and older pair. None of the pairs of stipules completely surrounds the bud.

When the buds begin to open the leaves turn down, and afterwards rise up again.

The young shoots and outer stipules are often a rich dark crimson, the next few pairs often a bright pink, greenish at the base; the following ones pale green.

MALPIGHIACEÆ.

Galphimia Humboldtiana, Bartl.—The stipules are connate between the petioles, forming a shallow, closely fitting cup around the axis, then adnate to the top of the pedestal, but thence free from one another and from the petiole; the free portions are small, ovate, concave on the inner face and imbricate.

Terminal bud consisting of decussating pairs of leaves, face to face. The expanding pair of leaves are concave, erect over the bud, but slightly apart. Their two pairs of stipules completely cover all the rest and lie in close contact, or are even slightly imbricate.

Axillary buds covered by long woolly hairs, and also by the imbricate stipules of the fully expanded leaves.

ZYGOPHYLLEÆ.

Stipules intrapetiolar, connate.

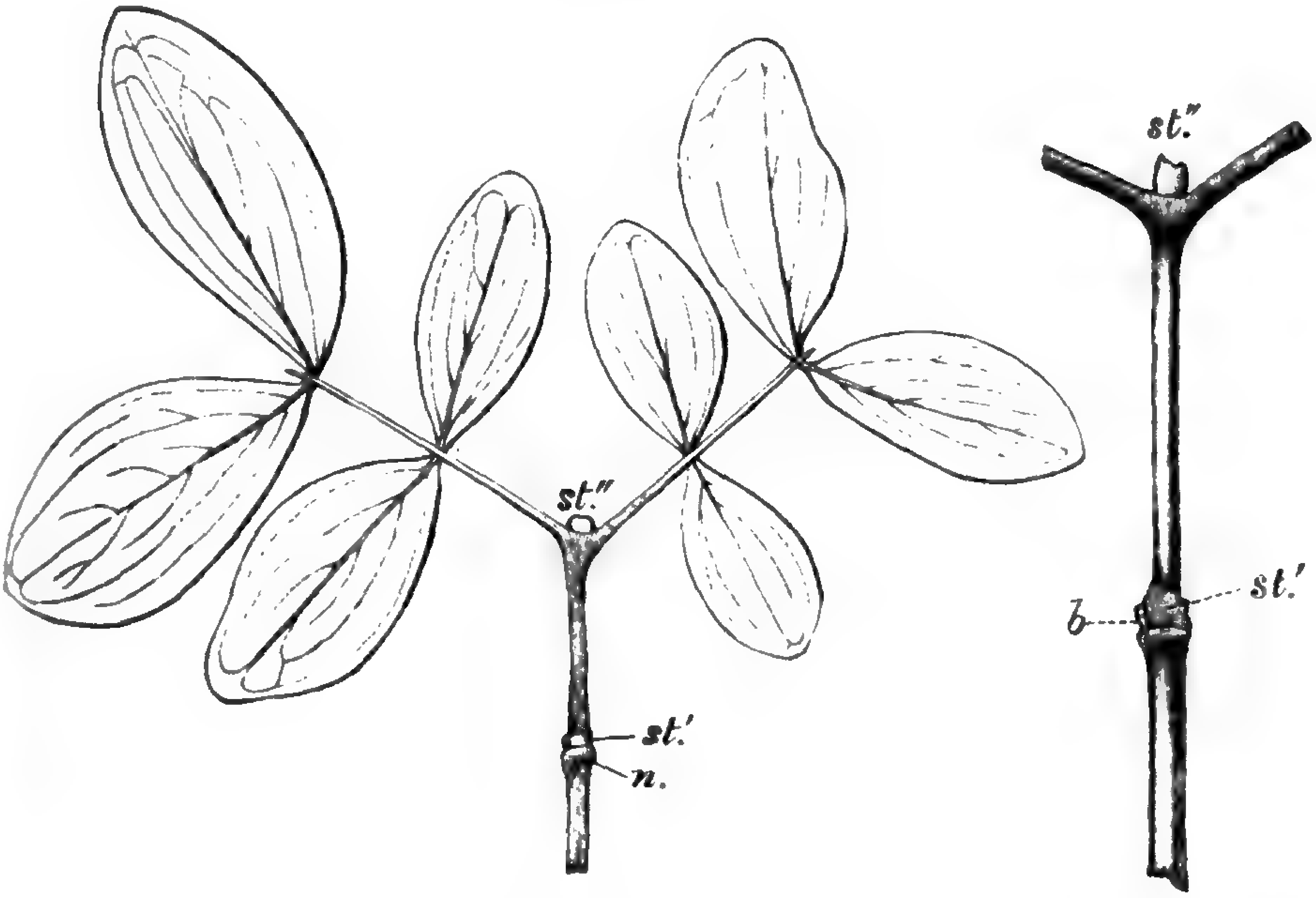
Guaiacum officinale, Linn. (figs. 6 & 7.)—Stem very hard, of slow growth, and forking or branching dichotomously. Leaves

opposite, in two ranks, not decussate, equally pinnate, with two pairs of elliptic, coriaceous, glabrous leaflets thickened at their insertion; during winter most of them fall away with exception of the terminal pair, which are persistent, and very few pairs are produced on each year's growth.

Petiole semiterete, somewhat dilated and thickened at the base, distinctly grooved above, articulate with the stem.

Stipules intrapetiolar, connate into a rounded piece on each side of the stem on which they are inserted, covering the space

Figs. 6 & 7.



Guaiacum officinale.

6. Terminal shoot, nat. size. $\bar{n}$, node; *st'*, connate stipules; *st''*, connate stipules covering the terminal bud.

7. Terminal shoot with lamina of leaves removed, ×2. *st'*, *st''*, stipules as in 6; *b*, lateral bud.

between the petioles but quite free from them, persistent even after the leaves have fallen, and only gradually getting broken away from the top downwards. In the 'Genera Plantarum' they are stated to be caducous, but this hardly appears to be correct.

Terminal bud completely enclosed by the stipules, which resemble two valves, as in many of the Rubiaceæ. The terminal winter-bud apparently seldom develops.

Axillary buds mostly arising from the axils of the last developed and persistent pair of leaves, and in the resting stage are covered by the stipules of the same. This would account for the apparent dichotomous branching of the stem. Those buds occurring lower

down the branches from whence the leaves have fallen are very small or inconspicuous.

Stipules small, subulate, spiny.

Porlieria hygrometrica, Ruiz et Pav.—Leaves opposite and distichous, not decussate, abruptly pinnate, petiolate, stipulate, silky or pubescent all over, except on the upper face of the leaflets; sensitive and persistent; leaflets linear-oblong, alternate, closing up and imbricate face to face when irritated or when circumstances are unfavourable. Petiole short, subterete, with a slender groove on the upper side, scarcely dilated at the base, recurving near the base when irritated.

Stipules in rather widely separated pairs between every two leaves, small, subulate, pale brown, hairy, spiny, erect, persistent.

Terminal bud covered by the two erect and connivent pairs of stipules belonging to each succeeding pair of leaves. The older pair of leaves push out from between the stipules, and gradually attain a considerable size before their leaflets unfold; they are densely hairy at this stage, and receive considerable protection thereby. Axillary buds developing tardily, and protected by the stipules of the leaves to which they belong, and later on by pale brown, hairy, membranous scales which appear to be stipules belonging to imperfect, and some to perfect, leaves on the axillary axis.

Geraniaceæ.

In my previous papers I described the stipules (Journ. Linn. Soc. (Bot.) xxx. p. 475) of certain species of *Oxalis*. Others are exstipulate. In *O. crenulata*, for instance, the leaflets are narrowed to the base and sessile upon a short sheath, and downy on the under surface.

Sheath triangular, open, semiamplexicaul, ciliate, erect, and adpressed to the axis, downy.

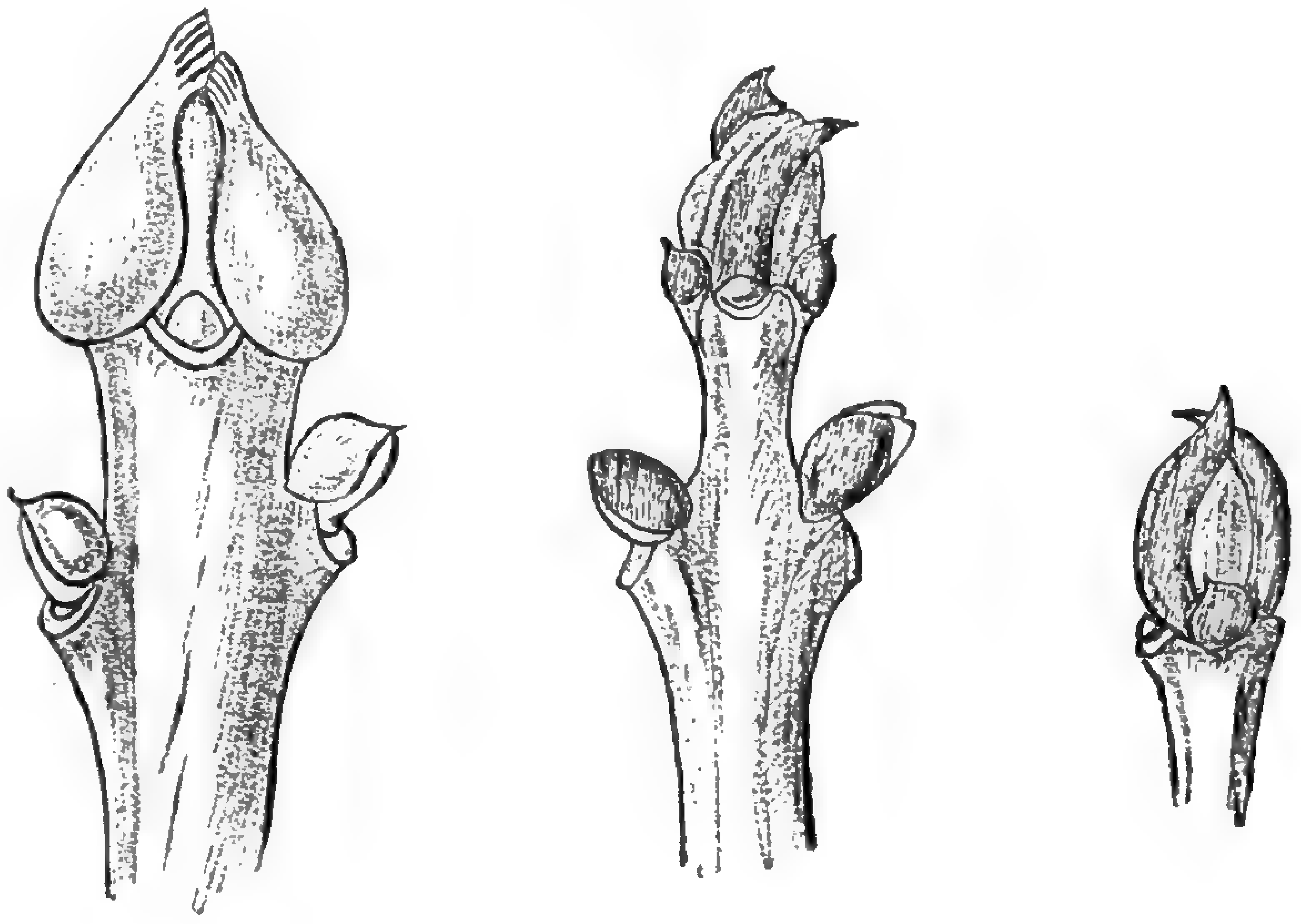
Terminal bud partly or wholly protected (according to its stage of growth) by the erect sheaths of the two most recently developed leaves. The leaflets are conduplicate and erect in bud, thus exposing the downy under surface only till they expand.

Axillary buds are not often elongated, but they are in all cases completely covered by the adpressed sheaths of the leaves till they attain some size. Sometimes one or two of the primary leaves are reduced to linear or subulate organs, and when confined to the base of the axillary shoots bear a superficial resemblance to stipules.

OLEACEÆ.

Ash (*Fraxinus excelsior*, Linn.).—The buds of the Ash are olive-green, so dark as to be almost black. The stems are much paler. The lateral buds are almost completely covered by the two outer scales. The scales of the terminal bud are often more or less bent. The scales are leaf-stalks, and generally show more or less rudimentary leaflets at the tip. The outer scales are thick and rather furry on the inner side. The second pair are furry on the outer side, and especially on the edges. The third pair still more so.

Figs. 8, 9, 10.



Ash buds, nat. size.

The outer scales are not dead, like those of so many trees, but increase more or less in size. The dark colour is due to a layer of black, more or less angular bodies, which are flattened hairs, containing a dark resinous secretion, and do not increase in size or number. As the scale grows they are therefore carried further and further apart, and occupying a smaller relative portion of the surface, the general colour becomes lighter and greener.

SAPINDACEÆ.

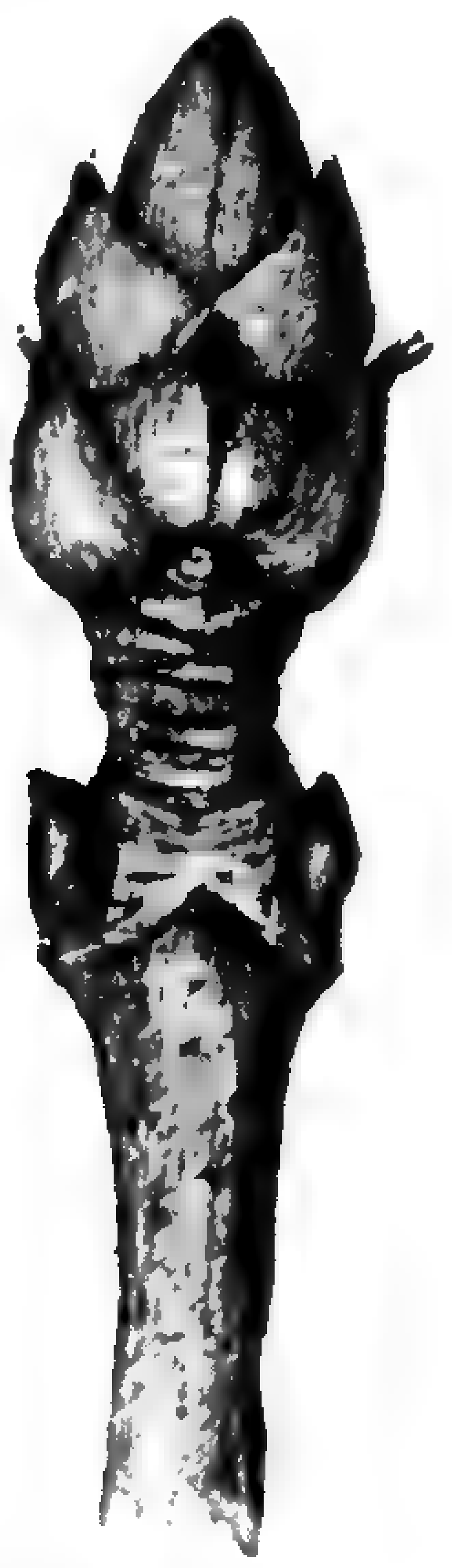
Æsculus Hippocastanum, Linn. (Horse Chestnut).—The bud is protected by 8 or 10 scales. The outer ones are dark brown and short; they are serially continuous with the leaves of the preceding year. Those following become gradually longer and paler —often pinkish towards the end. The inner ones have a delicate fringe along their edges. The outside of the bud is very sticky.

The scales are followed by normal leaves. Each segment of the leaf is conduplicate, and the midribs of the first, as well as the petiole and the internodes, are further protected by a thick felt, which is sometimes of a rich orange colour. This becomes less developed on the inner leaves, where it would not be so much wanted.

ACERINEÆ.

Acer platanoides, Linn. (Norway Maple).—The scales covering the bud (fig. 11) are, like the leaves, opposite and decussate. They represent the bases of leaves. The outer ones have a black tip which is sometimes trifid at the tip (fig. 11), representing the leaf,

Fig. 11.



Acer platanoides, × 2.

sometimes expanded into a small leaf. There are from four to six pairs gradually increasing in length, and in many cases (Pl. **13**. figs. 2, 3, 4) becoming pink. The upper pair show minute points at the tip—the rudiments of a leaf. They arch very prettily over the true leaves, showing a marked contrast both in form and colour. The leaves are green, and the petiole is narrow and round. The buds are not only protected by closely-fitting scales, but also by being somewhat sticky.

The outer scales are not dead, but increase in length, often considerably (Pl. **13**. figs. 2, 3), and arch over the young leaves. Some trees have a tendency to develop small leaves at the tips (Pl. **13**. fig. 4).

SABIACEÆ.

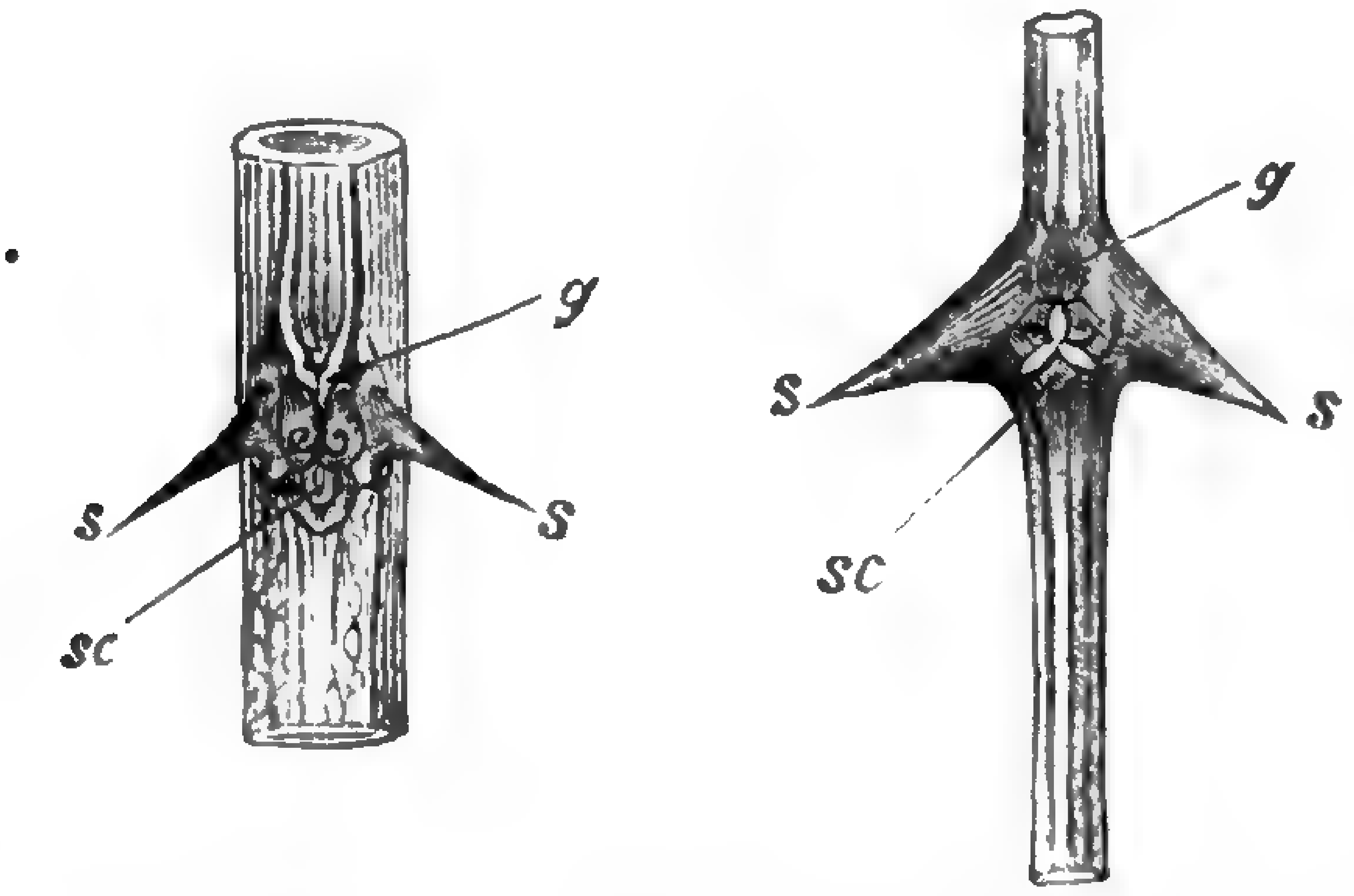
The Sabiaceæ are exstipulate. In *Meliosma pungens*, Wall.,

the petiole is short, convex on the upper surface, suddenly thickened and subterete at the base, and covered by a dense pubescence. The buds are densely tomentose.

LEGUMINOSÆ.

Robinia viscosa, Vent.—The stipules (fig. 12) of this species

Figs. 12 & 13.



12. *Robinia viscosa*, nat. size. *s*, *s*, spiny stipules sketched in winter (Jan. 25, 1897); *sc*, scar of fallen leaf; *g*, gland above the bud.

13. *Robinia Pseudacacia*, var. *Decaisneana*, nat. size. *s*, *s*, spiny stipules sketched in winter (March 13, 1897); *sc*, scar of fallen leaf; *g*, gland above the bud.

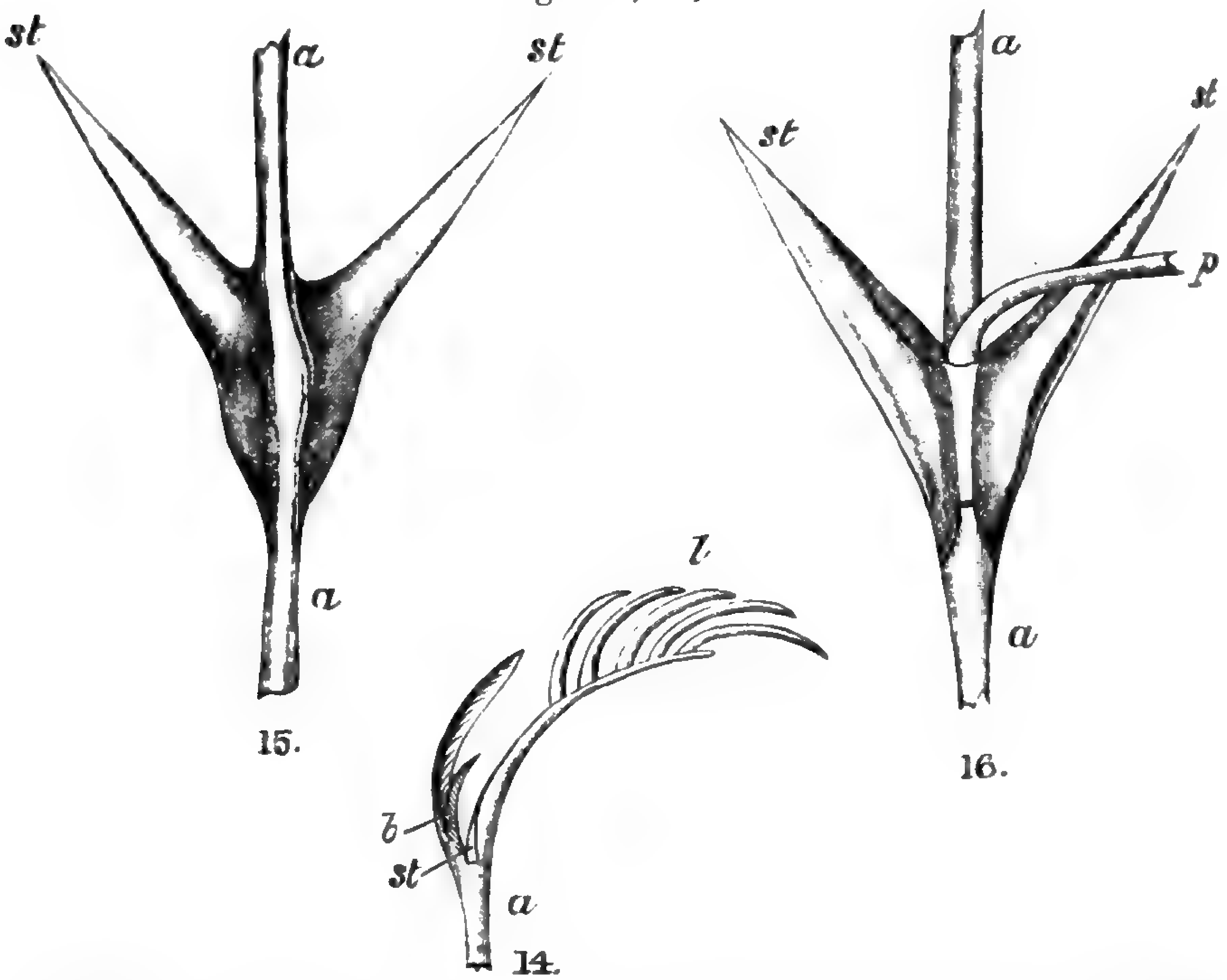
are subulate and at first soft, but ultimately they become much dilated at the base, compressed laterally, woody and spiny. Those on vigorous shoots only attain this development, so that adult trees are furnished with them only on those shoots that made vigorous growth the previous season, especially on the lower part of the tree. They are inserted right and left, just a little above the scar of the fallen leaf, with the lateral bud exactly between them. They vary greatly in size, being smaller towards the base and apex of the shoot bearing them. The larger ones are more or less directed downwards or deflexed, while the smaller ones are more or less horizontal. Their function seems to be for the protection of the tree, or its leaves and branches in general, against browsing animals. A gland is situated just above the small, inconspicuous, lateral bud.

R. Pseudacacia, Linn., var. *Decaisneana*, Carr.—The typical *R. Pseudacacia* has stipules resembling those of *R. viscosa* both in size and distribution; but the var. *Decaisneana* is a much more spiny tree. A very large proportion of the shoots, whether small or large, are furnished with broadly subulate, spiny stipules (fig. 13). The illustration shows the small bud between the

stipules, just commencing to burst in spring. A gland is here again situated just above the bud. The stipules are generally horizontal towards the apex of the shoots.

Acacia Hindsii, Benth.—The leaves are abruptly bipinnate, of

Figs. 14, 15, 16.



15. 16. 14.

14. Apex of young shoot, × 2. *a*, axis; *b*, bud; *l*, leaf; *st*, stipule, side view.
15. Stipules fully developed, back view, nat. size. *a*, *a*, axis; *st*, *st*, stipules.
16. The reverse of 15, showing the axis *a*, *a*; *p*, petiole of old leaf, gradually falling away.

large size, with numerous pairs of pinnæ and very numerous, small, linear-oblong, obtuse, slightly falcate leaflets, glabrous, persistent. Petiole subterete, grooved above, dilated and thickened at the base, articulate with a pedestal or elevation of the stem.

The stipules in their early stages are very small, fleshy, subulate and pointed, attaining a great size, spinescent, glabrous, green in the early stages, ultimately brown, persisting long after the leaves have fallen, and attached to the pedestal below the articulation of the petiole. While still in bud they lie in the concave space between two leaves. As the leaves fall away, a portion of the petiole decays more slowly. In the meantime the stipules enlarge, becoming spiny, divergent, brown, strongly ridged laterally, and 2·0–2·8 cm. long. The pedestal below the articulation also enlarges, till it is 12–18 mm. long, becoming large, woody, and brown.

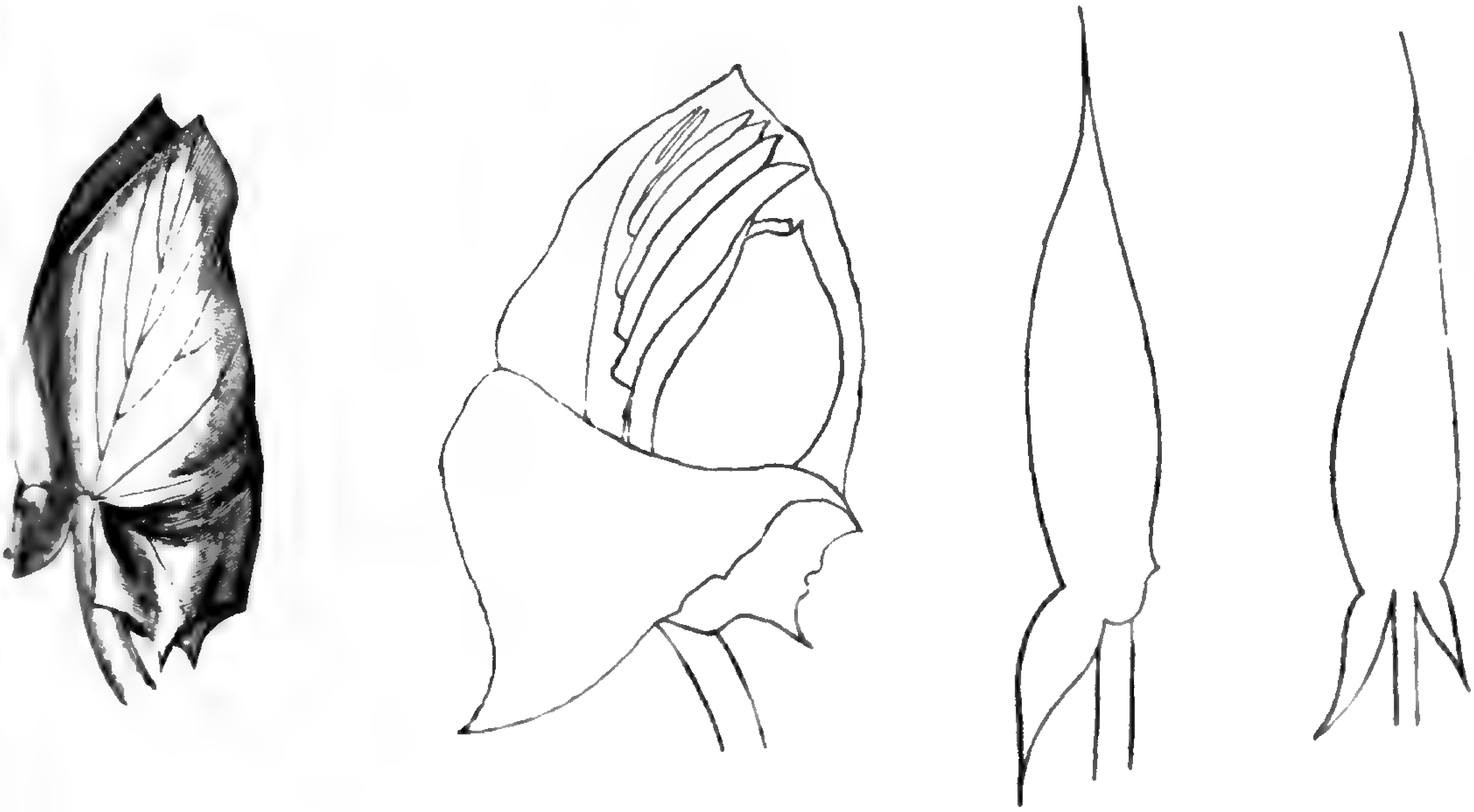
The stipules are of small size in bud, and apparently

functionless. As they get old they keep growing and hardening till they serve to protect the plant from browsing animals.

In the Peas and Vetches the stipules vary greatly in size and shape. Some (figs. 17 & 18) are large and broad, some long and narrow, these again being in some cases (fig. 19) sagittate, in others (fig. 20) half-sagittate.

Lathyrus maritimus, Bigel., belongs to the first category. The stipules (figs. 17 & 18) are large, foliaceous, and develop early.

Figs. 17, 18, 19, 20.



17. *Lathyrus maritimus.* 18. 20. *L. grandiflorus.* 19. *L. pratensis.*

All 1½ nat. size.

In *L. grandiflorus*, Sibth. & Sm. (fig. 20), they are half-sagittate, narrow and pointed. The upper and lower limbs moreover do not lie in the same plane, but are somewhat twisted relatively to one another.

In other species, as for instance in *L. pratensis*, they are sagittate.

Now if we open the bud of *L. maritimus*, we find that the young leaves and stipules occupy most of the space between the outer stipules, which cover and protect both the leaves and stipules of all the younger ones as well as the inflorescences and their own leaf in its earlier stages. They are sessile, cordate, unequally-sagittate, and glabrous like the rest of the plant, with numerous strong nerves radiating from the point of their insertion on the axis. The smaller auricle is generally ovate or triangular and entire; the larger one has three or four cusps or

teeth. The stipules form a very efficient protection to the leaves till they attain considerable size.

In *Lathyrus latifolius*, Linn., the upper limb of the stipule also protects the younger leaves, which, however, have only one pair of leaflets, and do not therefore occupy so much room. The stalk, however, being very wide is not covered by the sheathing-stipule. Consequently, if the upper one had a lower limb on the outer side, it would be exposed. The single limb, which is on the inner side, lies snugly ensconced between the stem and the older leaf. It is not therefore in the same plane as the upper limb. Moreover, the function of the stipule being to protect the young bud, it develops early, and where it is full-grown the lower limb (fig. 24) is equal in length to the internode below. Subsequently, however, the internode becomes much longer, while the stipule remains as before. But though the stipule may be correctly described as half-sagittate, it shows a minute tooth where the other barb would have been, indicating that it is descended from ancestors which had a barb on each side.

In *L. pratensis*, Linn., the stipules (figs. 19, 21, 22) are sagittate.

Figs. 21, 22, 23, 24.

21. 22. 23. 24.

Lathyrus pratensis. *Lathyrus latifolius.*

Here, however, the petiole is round, the wings lie one on each side of it (figs. 21 & 22), and are fully covered by the stipule of the preceding leaf.

Thus, then, the difference between the sagittate and semi-sagittate stipules appears to depend on the form of the stem and the arrangement of the bud. Where the stem is winged, the outer barb of the stipule would be exposed. In such cases the stipule is semisagittate.

In the Garden Pea (*Pisum sativum*, Linn.) the stipules are not only large in bud, and in arrangement resemble those of *L. maritimus*, but they continue to grow, and appear to act as a pair of leaflets.

Lathyrus Nissolia, Linn.—The first and second leaf (see 'Seedlings,' vol. i. fig. 284) are subulate, acute, and scale-like, with small and tooth-like or inconspicuous stipules. The third and all succeeding leaves are simple, entire, linear, slightly decurrent upon the stem, and have a strong midrib with more slender parallel lateral ones. They are alternate and distichous, that is on the ½ plan of arrangement, acuminate, and slightly narrowed to the base.

The third and all succeeding stipules are subulate, acute, slender, gradually becoming shorter towards the apex of the stem, and inserted on the edge of the decurrent leaf, where it is narrowed, and below the articulation with the stem. They appear to be functionless owing to their minute size.

The terminal bud is enclosed in successive, convolute leaves, which appear to be winged petioles without leaflets or tendril. They vary from 3 in. to 6 in. in length, and attain a considerable size before they unroll, after which they continue to be more or less concave, becoming slightly twisted. The axillary buds are sheltered in their axils. The terminal bud is amply protected by them. The plant forms a spreading tuft like a species of grass with coarse leaves.

Lathyrus Aphaca, Linn.—The first and second leaves (see 'Seedlings,' vol. i. fig. 285) are scale-like, and trifid, with three subulate points corresponding to leaf and stipules. The third and fourth leaves are compound, with one pair of leaflets and obliquely ovate stipules of considerable size, and having a tendril represented by a small subulate point.

The fifth and succeeding leaves are reduced to a subulate point, and a pair of triangular, foliaceous stipules. The subulate

point develops into a simple tendril on the middle and upper portions of the stem. The tendrils represent the leaves, and are alternate and distichous; that is, on the $\frac{1}{2}$ plan of arrangement.

The stipules are arranged in two ranks, inserted on the stem at right angles to the tendrils. They increase in size as the plant gains in vigour, and become obliquely triangular-hastate, but continue flat in bud and afterwards. The venation consists of numerous, parallel nerves, radiating from the point of insertion on the stem, the midrib being slightly the strongest.

Succeeding pairs of stipules overlap and protect all the younger members of the terminal and axillary leaf- and flower-buds, and tendrils. All lateral buds come in the axils of the tendrils. The stipules, therefore, perform the double function of leaves and the work of protection.

Rosaceæ.

Pyrus Aria, Linn.—The scales of the winter-bud (Pl. **13.** fig. 5, and figs. 25–35) of the White Beam-tree consist of the base of the leaf, that is the petiole in combination with the stipules. At the base of the winter-bud the persistent base of one or two leaves that fell in autumn may be found sheltering, it may be, axillary buds.

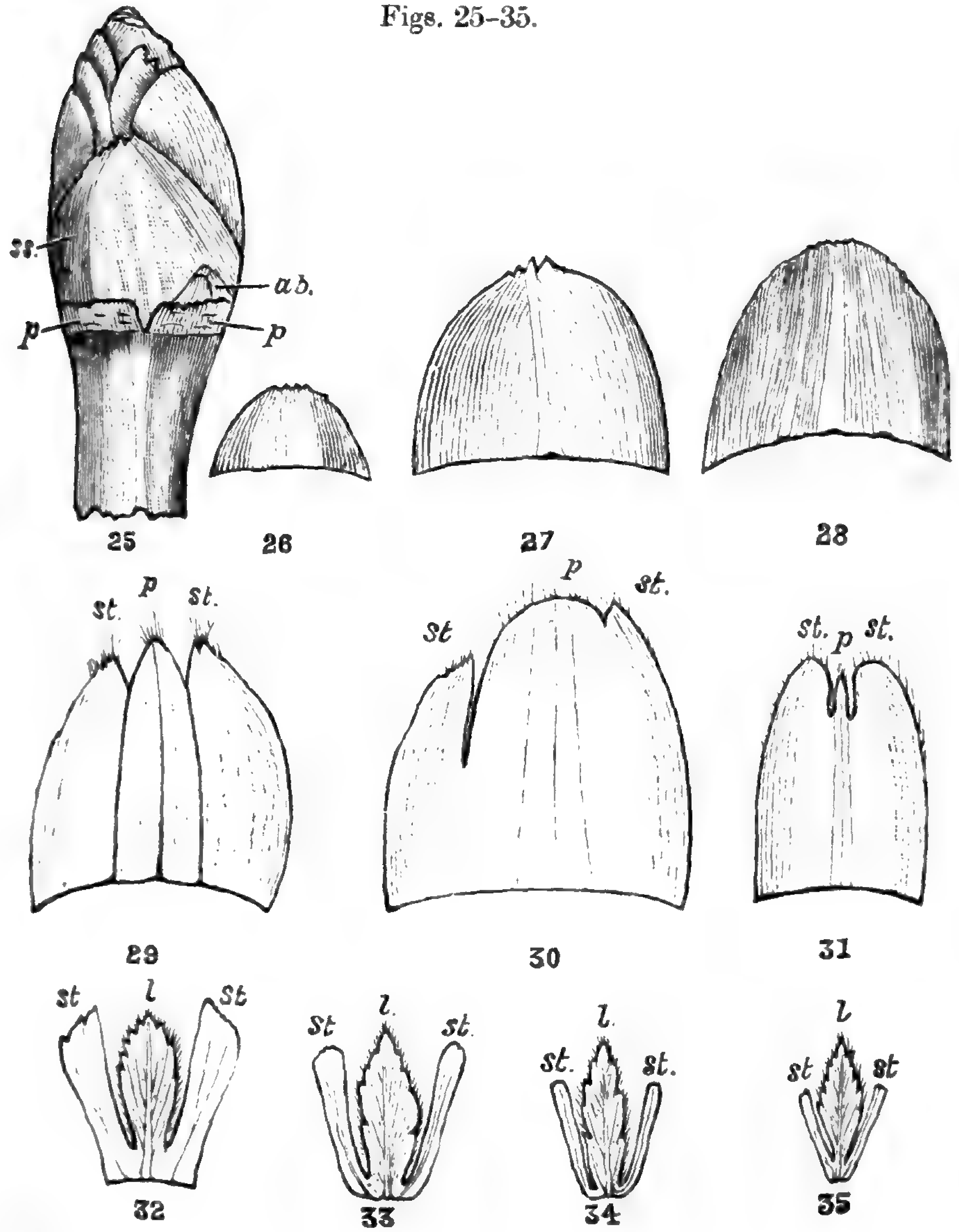
The first scale (fig. 26) is semicircular and slightly erose at the apex, but otherwise entire. The second (fig. 27) is several times as large, and obtusely carinate. The third scale (fig. 28) shows three ribs or nerves, and is about as long as the bud before growth is resumed in spring. The fourth is similar. The fifth scale (fig. 29) of a good-sized terminal bud (from which the sketches were made) was 3-ribbed, more membranous, greenish and trifid at the apex, thus disclosing the true nature of the scales, namely, a combination of the base of the petiole and the stipules. All the scales are rather firmly glued together by means of a viscid gum secreted from a cluster of orange-coloured glands situated close to the base on the inner face. The sixth is similar.

The seventh scale (fig. 30) is still more membranous, more faintly 3-nerved, enclosing a large portion of the bud, very unequally trifid, and enclosing $\frac{3}{4}$ of the bud. The eighth is tridentate, and shows a transition towards the true nature of its component parts.

The ninth scale (fig. 31) is oblong, much narrower, and trifid. The middle tooth is subulate-terete, subfleshy and red, being more like a petiole than in any previous scale. The three nerves are now closer together and directed into the petiole. The side

lobes or stipules are rounded. The fifth to the ninth scale inclusive are more or less woolly on the inner face.

Figs. 25-35.



Pyrus Aria.

25. Winter-bud: *p, p,* persistent base of fallen petioles; *a.b,* axillary bud; *ss,* second scale.
26. First scale. 27. Second scale. 28. Third scale.
29. Fifth scale: showing stipules, *st, st,* and petiole *p*.
30. Seventh scale: *st, st,* stipules; *p,* petiole.
31. Ninth scale: *st, st,* stipules; *p,* petiole.
32. *l,* first leaf; *st, st,* its stipules. 33. *l,* second leaf; *st, st,* its stipules.
34. *l,* third leaf; *st, st,* its stipules. 35. *l,* fourth leaf; *st, st,* its stipules.

At the tenth node a true leaf occurs (fig. 32). It is oblong-obovate, plicate, with ascending nerves, serrate, woolly, and slightly shorter than its oblong or spathulate membranous stipules, which show one or two nerves.

The leaf (fig. 33) at the eleventh node is lanceolate, and slightly longer than its linear, 1-nerved stipules. The third leaf (fig. 34) at the twelfth node is shorter and narrower, as are its stipules. The fourth leaf (fig. 35) at the thirteenth node is smaller, and shows a slight variation in being wider at the middle. The fifth, sixth, and seventh leaves, with their stipules, are gradually smaller, but otherwise similar.

The actual number of scales in the buds of the White Beam-tree varies a good deal, being fewer in the small buds as well as in the large ones containing an inflorescence. The outer scales are coriaceous, the inner ones membranous. The bud sketched was cut towards the end of April, when the inner scales had commenced to push out at the apex.

The leaves are covered, especially on the underside, with white felt. Whatever may be the position of the branchlet they stand quite upright, with the undersides outwards (Pl. **13.** fig. 5), so that they form a succession of intensely white pillars.

Cerăsus lusitanica, Loisel. (Portugal Laurel).—The outer scales are a deep crimson, the upper and inner ones rather paler. They have three more or less well-marked teeth at the apex. There seem to be generally five or six such scales. Then comes one with leaf and stipules about twice as long as the base. In the next few the stipules are longer than the leaf.

Potēntilla fruticosa, Linn.—The stipules are adnate to the edges of the pedestal, then quite free from the petiole, but connate along both edges, but to a far greater extent at the edges next the petiole, with two triangular free tips. They thus form an ocrea, much resembling that of Polygonum (see Tyler, 'The Nature and Origin of Stipules,' 1897, p. 44). Two strong nerves arise at the base of the petiole, one on each side, and pass into the free tips; they evidently represent the midribs of the two stipules. They are practically intrapetiolar above the articulation of the petiole; on the anterior edges they are only connate for half or less than half their length. They are so crowded on the short shoots as to completely cover the axis.

CAPRIFOLIACEÆ.

Vibŭrnum Opulus, Linn.—The winter-buds of the Guelder Rose, both terminal and lateral (Pl. **13.** fig. 1), are oblong-oval, varying considerably in size according to their situation on the shoots and the strength of the latter. Each bud is covered with

two pairs of scales, which are modified petioles bearing just a trace of an undeveloped lamina at the apex.

The outer pair of scales are the most modified, cohere by their edges, are inserted right and left of the axis, and likewise of the leaf in whose axils they occur. They are brownish-red, glabrous, shining, and for a time increase in size with the swelling of the buds in spring. Finally, they burst antero-posteriorly along the line of union for $\frac{1}{4}$ to $\frac{3}{4}$ of their length, the greatest amount of fission occurring, as a rule, along the posterior face, allowing the developing axis with its leaves to make its exit at the apex. Each of these scales is keeled, the keel corresponding to the midrib. Three or five veins may be seen on the inner face, corresponding to the principal vascular bundles running through the petiole into the lobes of the lamina. Three of them generally terminate in gland-like tips.

The second pair of scales are more membranous, pale green, five-nerved, reticulate, cohering in a tube, which bursts from the apex downwards for $\frac{1}{3}$ to $\frac{1}{2}$ their length, or more when growth is resumed in spring. They double their length during and after the expansion of the buds, and are therefore more intermediate in character between the most modified pair of scales and the true leaves. The three principal veins terminate in gland-like teeth, thus, possibly, indicating the presence of the lamina in an undeveloped state. When fully developed, they are seen to be spathulate by a dilatation of the upper half.

If the terminal bud is examined, it will be seen that the scales are opposite, decussate, and serially continuous with the uppermost pair of leaves that fell in the previous autumn. The young leaves in spring are serially continuous with both the two pairs of scales and the leaves of the previous season. Unless the terminal bud ends in an inflorescence, the shoots of successive years are interrupted only by two pairs of scales. Strong shoots, as a rule, terminate in an inflorescence, and the apex dies, so that growth is resumed by the lateral buds.

In the flowering buds the second pair are larger, vase-shaped, and also more deeply divided, especially on one side. Those which bear leaves only are flattened at right angles to the stem.

Viburnum Lantana, Linn.—In *V. Lantana* (figs. 36 & 37), on the contrary, the leaves are all normal. The outer ones protect the inner, but they all develop and suffer very little from the cold. They are protected by a thick coat of stellate hairs, which cross and intercross, thus forming a sort of grey felt. As the young

leaves increase in size these hairs do not appear to increase in number, and they are consequently carried further from one another. Fig. 37 is taken from such a leaf which had attained a length of rather more than an inch, × 75.

Figs. 36, 37.

Viburnum Lantana, × 2.

Part of leaf of *V. Lantana*, × 75.

Sambucus nigra, Linn. (Elder).—In the Elder the scales protecting the bud are petioles. Externally are a pair of very small brown scales; then a larger pair at right angles, then a pair much more elongated, greenish, and with more or less developed leaves. In this respect they differ very much: sometimes there are three small points at the summit, sometimes a well-formed leaf, and every gradation between the two occurs. The two opposite leaves often differ considerably, and when one of the two has its back to the main stem it is often much smaller than the outer one.

Stylidieæ.

In *Stylidium fruticosum*, R. Br., the terminal bud consists of numerous erect or slightly incurved imbricate leaves, the older protecting the younger.

The axillary buds are nearly all very minute, covered by the erect base of the leaf in whose axil they occur, and sheltered at the sides by the decurrent bases of two others, but they very seldom develop into branches. Where they do develop it seems to be always where the branching peduncles arise, or close to and touching them. Here they are protected by the erect or ascending and younger leaves near the tops of the shoots, till they have formed a number of leaves of their own, the older protecting the younger.

MYRSINEÆ.

In *Labisia alata*, N. E. Br., the terminal bud is surrounded by the long sheaths of the younger or more recently expanded leaves The sheath of the last developed leaf is completely rolled round it; and the edges are involute.

The axillary buds rarely develop, so that the stems are usually simple.

In *L. malouiana*, Linden & Rod., the axillary buds usually remain small, and in that stage are sheltered by the short sheath; but they are more frequently elongate than in the case of *L. alata*. One or two of the primary leaves are reduced to the condition of deeply concave bracts.

DROSERACEÆ.

Drosera rotundifolia, Linn.—Stipules scarious, linear-subulate, acuminate, colourless, adnate to the petiole for a short way above the base. On the smaller leaves of young plants there are one or two pairs of stipules superposed on the edge of the petiole. As the plant increases in size the upper pair of stipules or fringes decrease in size, while the lower pair are connected by a transverse or intrapetiolar line of three, four, or more, making five, six, or more independently of the slender and decreasing upper ones.

The terminal bud is covered by numerous stipules from the more recently developed leaves, forming a loose fringe over it. The leaves are circinate in bud.

The axillary buds are seldom developed, but when present are covered and protected by the dilated and imbricate bases of the petioles.

Drosera spathulata, Labill.—Leaves radical, densely rosulate and imbricate, sessile, stipulate, spathulate, gradually narrowed to the base, furnished with glandular tentacles on the upper

half of the upper surface, glabrous downwards, but ciliate and pilose beneath, slightly dilated again at the very base, with narrow membranous margins there.

Stipules scarious, colourless, intrapetiolar, and inserted a little above the base, tripartite as a rule, with the two lateral segments linear subulate, and decurrent upon the edge of the petiole, forming the membranous margin, while the middle segment is broadly subulate and more or less fringed at the apex.

Terminal bud sheltered by the stipules, which project towards the axis, while by a slight bending of the base of the petiole they are nearly at right angles to the lamina.

Axillary buds rarely develop, so that the crown or rosette is solitary even after many years. Should a bud arise it would be more than protected by the imbricate leaves and their stipules.

In *Drosera binata*, Labill. (syn. *D. dichotoma*), the leaves are radical, with long petioles, stipulate, with the lamina forked or seemingly dichotomous, covered on the upper surface with tentacles of various lengths, and tipped with a red gland; petiole long, slightly flattened, biconvex, glabrous, not dilated at the base. The stipules are inserted at the very base of the petiole and seemingly upon the axis in all cases; the interpetiolar ones are subulate, sometimes ovate, and glandular serrate; the intrapetiolar portion is short and more or less deeply incised; all are persistent. The terminal or axial buds are small and covered by the intrapetiolar portion of the stipules. The axillary buds are not developed till the plants attain some size at least.

In *Pinguicula caudata*, Schlecht., the central or terminal bud is covered by one, or at most by two leaves. The latter are erect at this stage, rolled round the younger members and involute at the margin. A leaf in the process of expansion leaves a small portion of the next younger one exposed; but the latter completely surrounds all the rest, while its own margins are also involute.

Axillary buds develop during the course of the season, but remain hidden amongst and covered by the leaves. When the latter die down the buds are in the form of small bulbs consisting of imbricated leaves, and which become detached as offsets.

CACTEÆ.

The Cacteæ are exstipulate. In *Pereskia*, which, however, is an abnormal representative of the Order, the petiole is semi-

terete, but slightly dilated at the base, and channelled on the upper surface. The terminal bud consists of many leaves firmly wrapped round one another. The axillary bud is very minute, and completely covered with a dense cushion of dark brown hairs, the marginal ones of which are much longer, more woolly and grey. These buds seldom develop into branches, but in any case they are well protected by the cushion of hairs till they attain some size. Many of them are furnished with a hooked pair of sharp spines, one on each side of the petiole, and curved downwards. They seem intended to assist the plant in climbing.

ARALIACEÆ.

Oreopanax reticulatum, Dcne. & Planch. (syn. *Aralia reticulata*, Willd.).—Leaves alternate, petiolate, stipulate, linear, entire, 30–50 cm. long, narrowed insensibly into the petiole, coriaceous, glabrous, persistent; petiole very short, and that portion which is entirely free from the lamina is suddenly thickened, but not so wide as thick at the base.

The stipules are acuminate, intrapetiolar, connate into an ovate piece, membranous, and caducous.

The terminal bud consists of numerous leaves and stipules, the latter affording a considerable amount of protection and falling away on the expansion of the leaves, which lengthen gradually after they have left the bud.

The axillary buds are rarely developed on young plants, at least unless the terminal one is injured or destroyed. Plants 2 m. high would be altogether unbranched. This would appear to be the reason why the stipules are caducous on the expansion of the leaves of the terminal bud.

LENTIBULARIEÆ.

Utricularia montana, Jacq.—Leaves radical, in small rosettes, petiolate, exstipulate, lanceolate, entire, coriaceous, glabrous, and, with exception of the midrib, the venation is obscure; petiole biconvex towards the upper end, with the midrib slightly raised on both surfaces, terete towards the base, finely pubescent and not dilated.

The rootstock forms a small fleshy nodule, from whence the leaves appear to arise at different places. Numerous branching and fibrous roots are given off below and are covered with minute transparent bladders.

Bud very small, fleshy, turned on one side of the small fleshy rootstock. It is generally almost covered by the moss or other vegetation amongst which the plant is growing, so that it is practically subterranean and thereby sheltered.

BIGNONIACEÆ.

Catalpa bignonioides, Walt.—The *Catalpa* is late in coming into leaf. The phyllotaxy of the leaves is ($\frac{1}{3}$), there being three leaves in a whorl. The portion of a shoot shows a whorl of three buds all at different levels on the axis, a circumstance brought about by the inequality of the growth of the axis. The leaves of the previous season were unequal at every node. The buds are also very unequal after growth has been resumed in spring for some time. In winter, however, they are minute.

The scales of the winter-bud consist apparently of leaves. They are arranged in decussating whorls of three. The first and second whorl consist (May 13th) of minute, triangular, brown, coriaceous scales, which are sufficiently large to cover the bud in winter, and do not enlarge in spring. They overlap in winter, but soon separate in spring as the bud enlarges.

The third whorl consists of broadly triangular cuspidate scales, slightly carinate towards the apex, which is the only portion exposed in winter, the rest being green and enlarging in spring. The scales of the fourth whorl are ovate, obtuse, obtusely carinate, green, glabrous, and greatly increase in size before the expansion of the bud.

The scales of the fifth whorl are oblong-lanceolate, subacute, obtusely carinate, somewhat narrowed at the base, and thinly covered with a mealy, glandular pubescence.

The sixth whorl consisted of ovate, obtuse, entire, petiolate, penninerved leaves as long as the bud, with ascending nerves, and thinly covered with mealy, glandular pubescence. The change from scales to leaves is very abrupt, the most marked features being the petioles, the strongly marked venation (of which a trace could be detected in the fifth whorl of scales), and the membranous portion of the lamina being red.

The seventh whorl or second set of leaves, and every succeeding one up to the twelfth or more, were successively much smaller and colourless, but otherwise similar to the first set of leaves. Though the largest in bud the latter do not, as a rule, get very large compared with succeeding leaves.

The above description was taken from a medium-sized lateral bud. Others show some variation in the number of whorls of scales previous to the true leaves; and there is also some variation in shape, but only of minor importance. I did not detect the three-lobed character to be seen in the very largest of the adult leaves. The lobes seem to develop after the leaves attain some size.

In *Tecoma grandiflora*, Delaun., the petiole is semiterete, grooved above, dilated at the base, and connected at the base by a slightly elevated ridge, which is furnished with a fringe of hairs, readily becoming disarticulated.

Terminal bud in the resting stage covered by about four decussating pairs of broadly triangular scales, which evidently consist of a reduced leaf; all are more or less pointed, but the inner ones elongate considerably upon the resumption of growth, and their points are more or less furnished with teeth or serratures foreshadowing the leaflets of the perfectly developed leaves. The leaves of the growing bud are compactly folded face to face, so that the midrib and the secondary ones or midribs of the leaflets are the first portions to become exposed. The leaf, as a whole, attains a large size before the leaflets unfold.

Axillary buds are sheltered by the broad petioles, by a fringe of hairs in front of the latter, and by their own scales.

The use of the fringe of hairs connecting the base of the leaflets, and also the base of petioles, is not very obvious. They may render additional protection in the bud stage.

The buds are covered by every three leaves of a whorl in succession.

Phyllarthron comorense, Boj. (figs. 38, 39).—Leaves verticillate, in whorls of three, the whorls decussating, linear, consisting of two to five joints, coriaceous, glabrous, narrowed to the base, sessile, much thickened at the insertion. Each joint is widest at the apex, where it is rather deeply emarginate to receive the insertion of the joint next above it, and which is narrowed and rounded at the base. The whole leaf is therefore very much constricted at each articulation, and looks like a compound leaf reduced to a winged midrib.

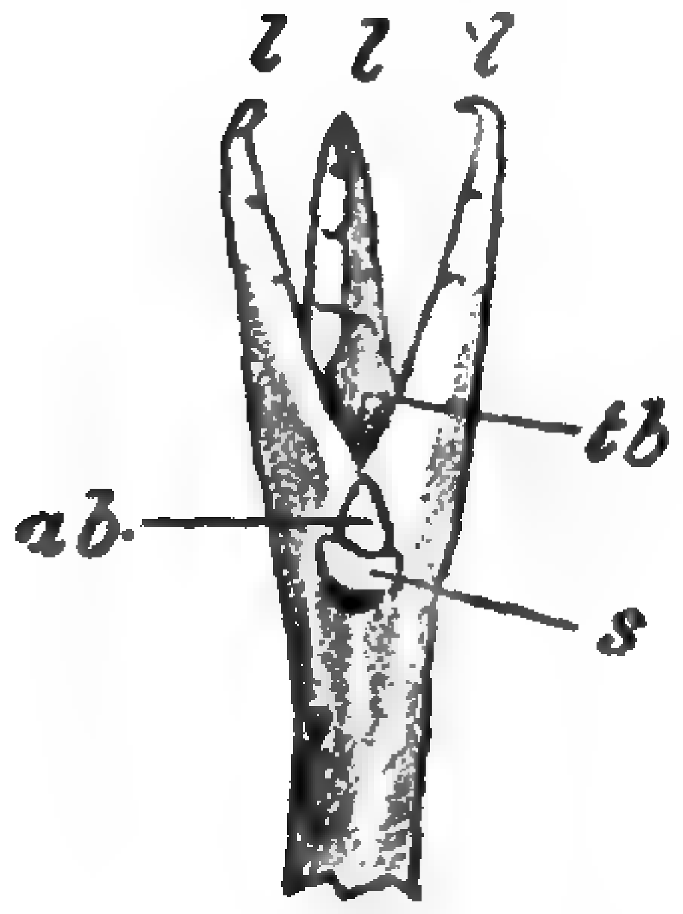
The stem is triangular, with very short internodes; the angles of each internode alternate with those above and below them, dependent upon the insertion of the whorls of leaves.

The terminal bud, even in the growing stage, is triangular and

entirely covered by every three leaves in succession. The angles of the bud alternate with each succeeding whorl of leaves. The

Fig. 39.

Fig. 38.



Phyllarthron comorense.

38. Bud just commencing to elongate, × 4. *l l l*, young leaves still in their subconduplicate stage; *t.b*, terminal bud; *a.b*, axillary bud; *s*, scar of fallen leaf.

39. Full-grown leaf. ⅓ nat. size.

latter in the bud are very narrowly linear, grooved along the centre, and consist of a very strong midrib with narrow slightly incurved margin, and the articulations are scarcely discernible.

The axillary buds are small, inconspicuous, covered with what apparently would remain in the condition of scales if the buds were to resume growth, and nestling in the axils of the dilated base of the leaf. They seldom develop unless the terminal bud is destroyed, accidentally or otherwise.

Myoporineæ.

The Myoporineæ are exstipulate.

Myoporum tuberculatum, R. Br.—The terminal bud consists of

numerous leaves convolute round one another and exuding a resinous fluid, by which they are rendered viscid or gummy. The outermost leaf would cover the whole of the upper part of the bud, but only two-thirds of it below the middle; a second leaf covers the greater portion of that left exposed by the first; and the three succeeding ones show their petiole or a portion of it only. Therefore, although one leaf covers the greater part of the long tapering bud, five are necessary to completely cover it.

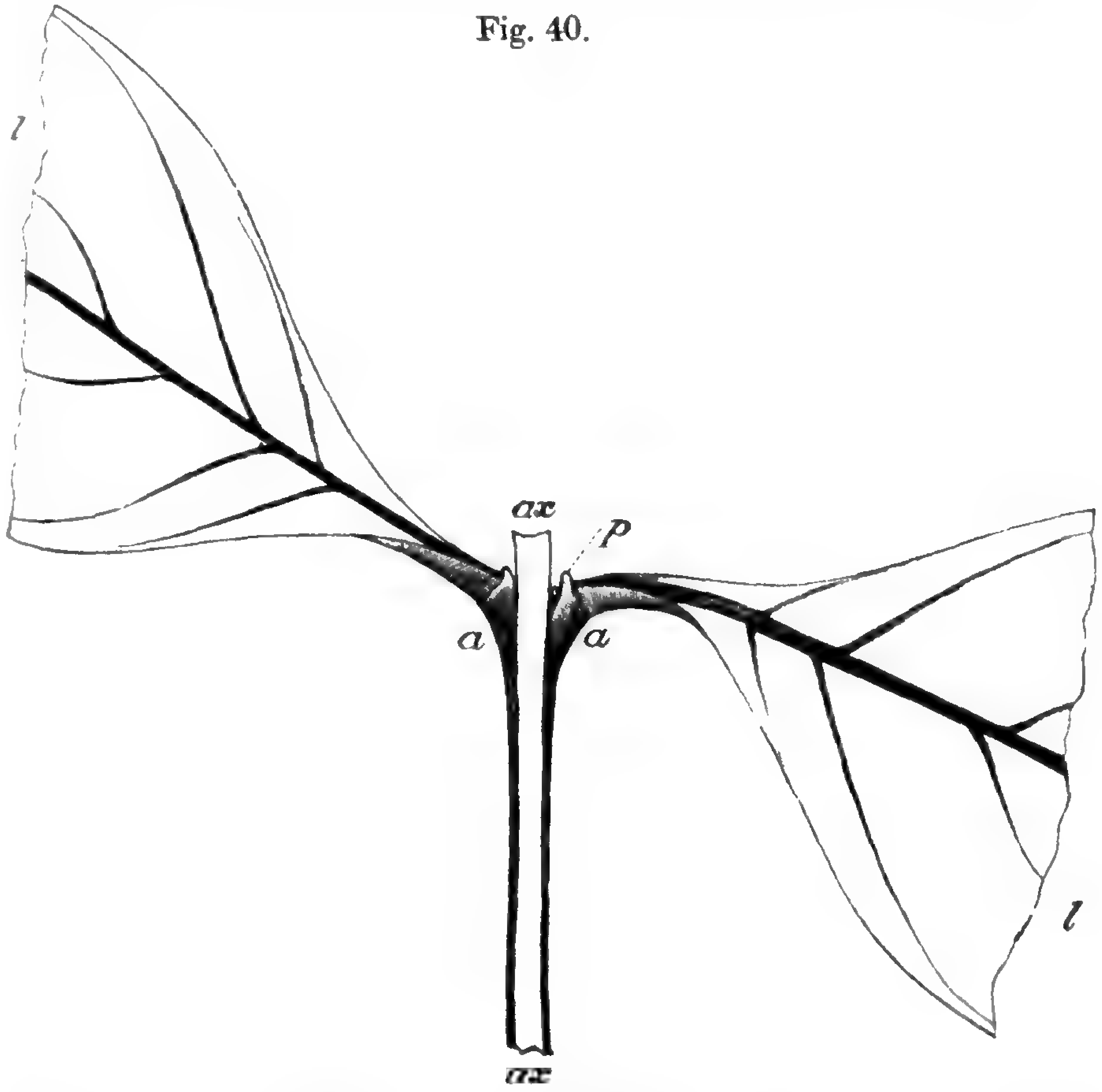
Axillary buds arise in the axils of leaves that are still quite young. They are then covered by the petiole, which is more or less erect at this stage. The first leaves, like the rest, are glandular and gummy, and must afford a considerable amount of protection.

Verbenaceæ.

The Verbenaceæ are exstipulate.

Citharexylum quadrangulare, Jacq. (fig. 40).—The axillary buds are completely covered by the concave and tongued pedestal.

Fig. 40.



Citharexylum quadrangulare, nat. size.

Ax, *ax*, axis of shoot with portions of a pair of leaves, *l l*; *a*, *a*, articulation of the leaves above persistent sheathing pedestals, one of which, *p*, is slightly opened to show the axillary bud it covers.

The terminal bud in the growing state consisting of leaves partly conduplicate or folded along the middle, then involute at the margins and placed face to face, but not overlapping or interlocking with one another. They attain some size before expanding, and each pair covers the next younger pair.

PEDALINEÆ.

Craniolaria annua, Linn.—The terminal bud emerges from between the bases of the youngest expanded pair of leaves. Each succeeding pair of leaves covers the next younger pair completely while in bud. The edges of the younger leaves lie in the channel of the midrib of the older ones.

The axillary buds in the younger stages are protected by the thick petiole, by glandular hairs, and more or less by the leaves above them, while the petiole is yet short.

PHYTOLACCACEÆ.

Rivina lævis, Linn.—Leaves alternate, petiolate, ovate or oblong-ovate, finely downy on the midrib and principal nerves, but particularly so beneath; petiole grooved above, slightly dilated at the base, with a depression or cavity there, narrowly margined, with the margins decurrent upon the stems, forming slightly elevated ridges. The 'Genera Plantarum' describes the stipules as minute and caducous, but the only organs possessed by the plant and comparable to stipules are two or more conduplicate leaves of unequal size, and having the primary lateral nerves quite apparent. They are situated in front of the petiole and close to the sides of the axillary bud, of which they are the first two leaves, seemingly opposite by the internodes not being developed, but evidently alternate, judging by their unequal development.

The terminal bud consists of numerous conduplicate leaves, sheltering one another to some extent.

The axillary buds arise close to the apex of the stem while the leaves in whose axils they occur are quite young; at this stage they are sheltered in the groove of the petiole and that of the stem, and later on receive protection for a short time from the first two leaves which they develop.

Rivina lutea, hort.—Leaves broadly ovate, and all parts of them, including the petioles as well as the stems, densely downy. This downy condition helps to protect both terminal and axillary

buds. The specimen examined did not show any leaves developed from the base of axillary buds and resembling stipules, as in *R. lævis*, but that may be dependent upon a certain stage of growth.

Rivina purpurascens, Schrad.—The terminal bud in the growing stage consists of numerous conduplicate leaves, closely crowded together, but not enclosing one another; the older shelter the younger. These leaves attain a considerable size before unfolding, and as they open the edges become involute and continue in this condition for some time while the leaf is enlarging.

The axillary buds are protected in their early stages by an ovate or triangular, fleshy, deep green process that is intrapetiolar, inserted at the very base of the petiole, but to all appearance belonging to the axillary bud itself. This organ is convex on the face next the petiole and flattened against the axillary bud. It arises while still within the leaves of the terminal bud and for some time completely covers the axillary one. The first two leaves of the latter develop almost simultaneously, but one is really slightly in advance of the other and ultimately becomes distinctly alternate. These leaves are conduplicate and at first appear like stipules, but finally reach perfect development.

Rivina humilis, Linn.—The leaves are smaller than in the preceding species, densely and conspicuously pubescent, so that the young leaves, particularly while in bud, must derive benefit from the additional protection.

The intrapetiolar scale is well developed from an early stage onward and is deep olive at first, becoming pale brown after a time. As in the preceding species, the scales develop into leaves.

The terminal bud is protected by the densely downy covering of the under surface of the three to five exposed leaves during the progress of growth, and partly also by the axillary buds.

The axillary bud consists entirely of fleshy, undeveloped leaves, well advanced even while the terminal one is only in the progress of development. A transverse section through the apex of this fleshy bud shows (1) one large leaf that is merely an undifferentiated midrib or petiole, and (2) the tip of another that is less than a quarter of the size of the first. Another section lower down shows four or five leaves *in situ*, all of different sizes and consisting of a reniform midrib, the sides of the sinus corresponding to the commencement of the parenchymatous and

membranous portion of the leaf. Still lower down, the section shows differentiated tissues of an axial nature.

Clearly, then, there are no stipules, and the fleshy protuberance in front of each leaf-stalk is the first leaf of an axillary shoot.

Petiveria alliacea, Linn.—The stipules are small, fleshy, erect, subulate, flattened on the inner face, obtusely keeled on the back, drying up and falling with or slightly before the leaves, and, like the latter, in due succession. They are perfectly free and lie in front of the petiole in their early stages, but afterwards spread at right angles to the axis or nearly so.

The terminal bud is protected by the oldest not yet expanded leaf, which folds over it, protecting all but the midrib of the second leaf. All are sessile or subsessile at this stage and downy on the back. The erect petioles of the younger expanded leaves also afford some protection.

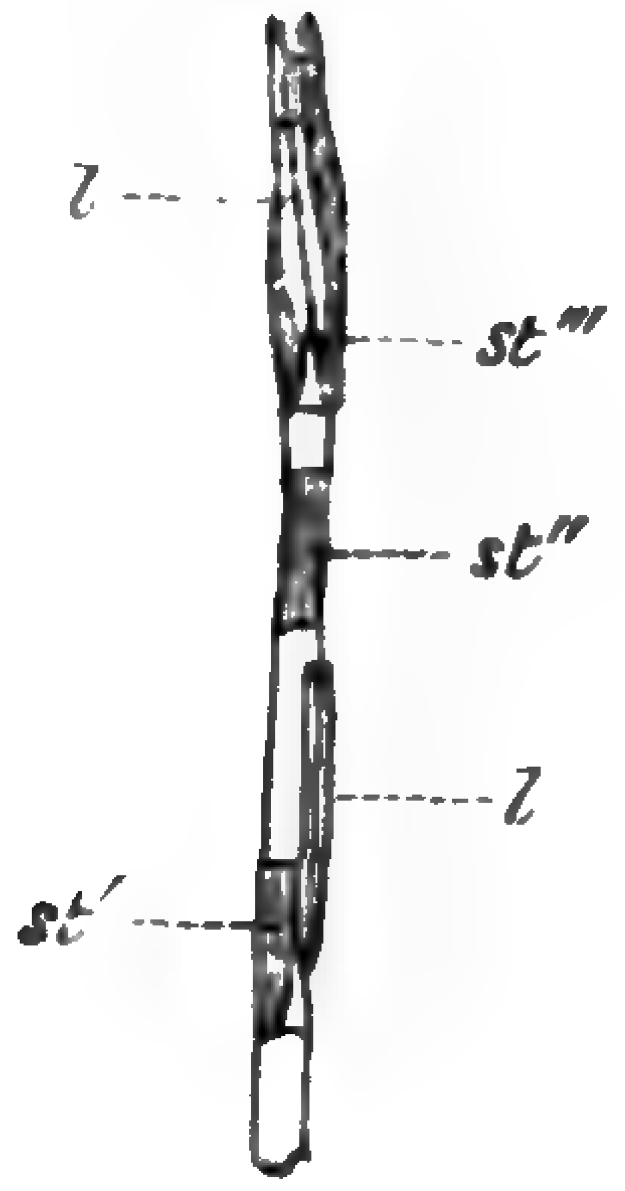
Axillary buds protected by the ascending or erect petioles, and in their early stages more particularly by the stipules, which are inserted at their base, folded over them in front of the petioles, and filling the space between the latter and the axis. The first leaves of the axillary shoots are very hairy and also furnished with stipules.

POLYGONACEÆ.

Muehlenbeckia varians, Meissn. (fig. 41).—The stipules are in the form of membranous ocreæ, cylindrical in form, closely investing the axis, truncate, and entire.

The terminal bud consists of a number of leaves closely invested by the ocreate stipules.

Fig. 41.



Muehlenbeckia varians, nat. size.
Apex of growing shoot. *l l*, leaves revolute at the margin, and yet unexpanded: *st'*, *st''*, *st'''*, stipules, shaded and striated.

PIPERACEÆ.

Peperomia trinervis, Ruiz & Pav.—The terminal bud consists of subsessile and sessile, convolute leaves, the outer of which covers two-thirds of all the younger members; the next younger leaf covers all the rest. The leaves attain some size before they unroll.

The axillary buds are very small the first year they are formed and nestle in the concavity of the pedestal. They do not, as a rule, elongate the first season, and often not at all.

EUPHORBIACEÆ.

Jatropha podagrica, Hook.—Leaves alternate, petiolate, stipulate, peltate at the base, shallowly 3–5-lobed, glabrous; petiole terete, slightly and very gradually thickened at the base, glabrous.

Stipules inserted at the very base of the petiole and partly on the stem, much branched, and fleshy, with terete pale green branches, tipped with deeper green glands, ultimately woody, spiny, and persisting on the short, stout, fleshy stems long after the leaves have fallen. Their function in their later stages is evidently meant to afford some protection against animals. The species is a native of Santa Martha, and would appear to be subject to periods of prolonged drought judging from the fleshy character of the stem.

Phyllanthus montanus, Sw.—Leaves alternate, distichous, small, bract-like, subulate, acuminate, sessile, deep brown, dry, membranous, persistent. They are inserted on the edges of somewhat flattened branches and also at much shorter intervals upon the edges of linear-lanceolate, deep green, and shining branchlets, simulating true leaves. These cladophylla are much flattened and thin for branchlets, but are leathery with numerous ascending, slender nerves, and bear the flowers in the axils of the reduced or modified and bract-like leaves.

The stipules are very similar in size, form, and texture to the leaves, and equally persistent.

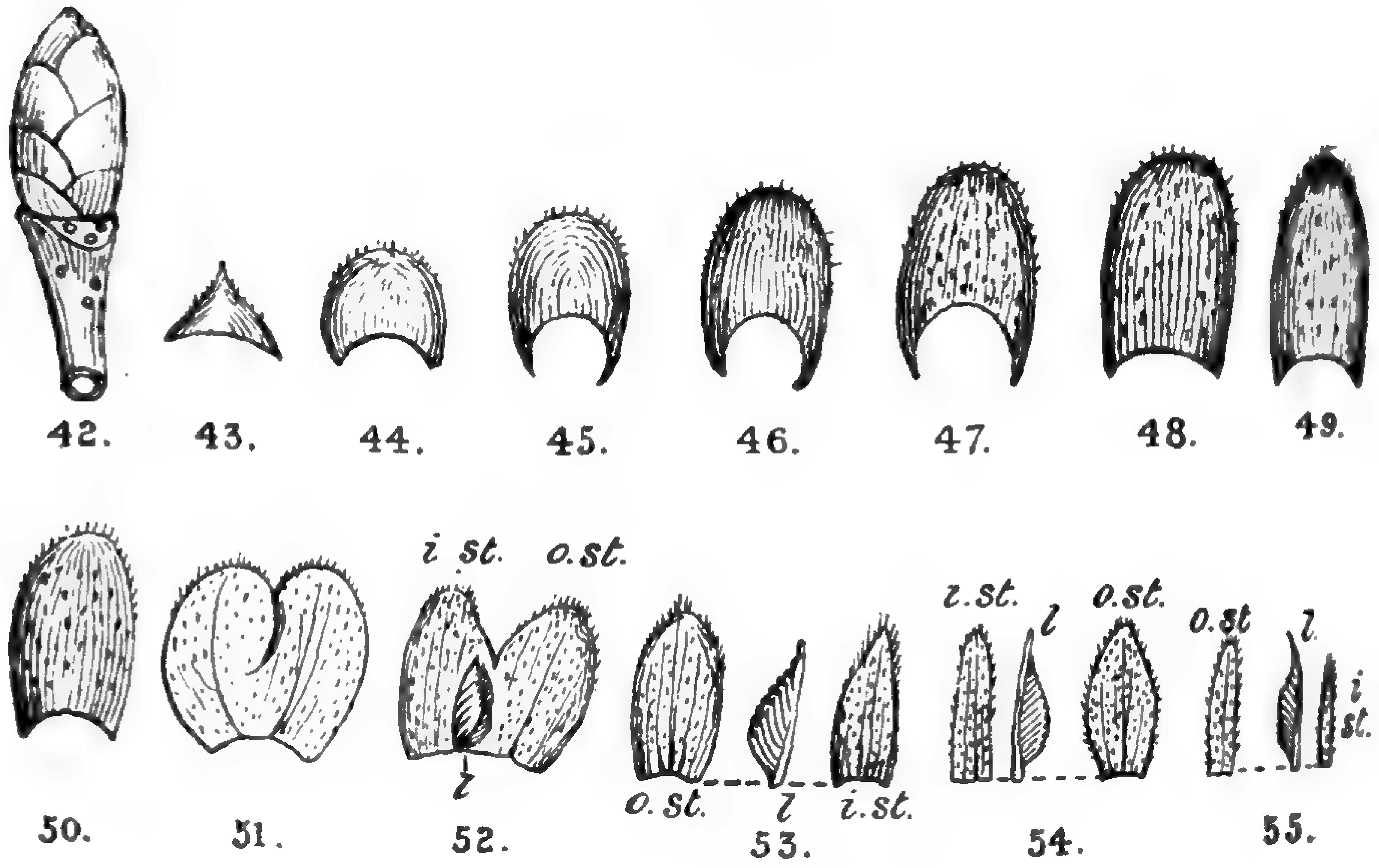
The terminal bud is ovate, flattened, small, and covered by an imbricating mass of leaves and stipules.

The axillary buds are protected in their early stages by the leaves and stipules. Those on the flattened leaf-like branchlets are very much smaller than the terminal ones, but otherwise similar.

URTICACEÆ.

Ulmus campestris, Linn. (Common Elm).—The buds (fig. 42) of the English Elm are oval in form. The scales are arranged alternately and distichously, and consist of stipules. Each of the outer scales consists of a pair of connate stipules.

Figs. 42–55.



Ulmus campestris.

42. Terminal bud, showing seven scales.
43. The first scale.
44. The second scale.
45. The third scale.
46. The fourth scale.
47. The fifth scale.
48. The sixth scale.
49. The seventh scale.
50. The eighth scale.
51. The ninth scale, showing fusion, which is unusual.
52. *o.st*, outer stipule with a portion removed to show the leaf, *l*, which comes next in order; *i.st*, inner stipule.
53. *o.st*, outer stipule; *l*, leaf; *i.st*, inner stipule. All are separated to show outline.
54. *o.st*, outer stipule; *l*, leaf; *i.st*, inner stipule.
55. *o.st*, outer stipule; *l*, leaf; *i.st*, inner stipule.

The outer four stipular scales are coriaceous, dark brown, brittle, more or less ciliate towards the apex, and in the case of terminal buds serially continuous with those of the previous year. Owing to their being connate, however, the single piece occupies the position of the leaf which, if present, would be between them. These four scales do not elongate in spring, being practically dead; they usually split at the apex into four or five teeth.

The first scale (fig. 43) is widely triangular and generally acutely cuspidate. The second (fig. 44) is nearly orbicular,

deeply concave, and covering a considerable portion of the bud. The third (fig. 45), fourth (fig. 46), and fifth (fig. 47) are more oblong, gradually longer, each covering a large portion of the bud and overlapping the scale next above them. The fifth is more membranous and pubescent, remains alive during winter, and elongates on the resumption of growth in spring. It is strongly or copiously ciliate, but particularly above the middle. The sixth (fig. 48) is longer, but otherwise similar.

The seventh scale (fig. 49) in an average bud is the longest, covers about ¾ of the bud, and being folded over or round the top of the bud, all the scales that follow are slightly shorter. The eighth (fig. 50) is more narrowed at the base. All these scales from the fifth onwards are furnished with longitudinal slender veins, running almost parallel from base to apex.

The ninth scale (fig. 51), in the bud from which the sketches were made, was divided halfway down, one lobe overlapping the other. Each half was furnished with a distinct midrib, with a few more slender ones proceeding from it. Here we have evidence of these scales being made up of two stipules. Other buds I examined contained several divided scales.

The tenth node of the same bud bore two perfectly distinct, broad, oblong stipules, with a leaf between them (fig. 52). Other buds I examined showed that the fifth or often the seventh scale had reached this stage; so that individual buds vary according to size, vigour, and other circumstances. The stipules have a midrib and overlap one another. All the leaves are conduplicate, alternate, and distichous; and as they lie against the sides of the axis with their edges to the sky, it follows that when figured on a flat surface their edges appear to be turned in opposite directions at each alternate leaf. This is due to their distichous arrangement.

The eleventh pair of stipules (fig. 53) in the same bud were very unequal, the outer being the larger, oblong, and having the edges of the leaf lying beneath it as usual. The inner stipule was oblong-subulate. The twelfth pair (fig. 54) were also unequal, the larger one being oblong-lanceolate and the smaller linear. The leaf equalled its stipules in length. The thirteenth pair (fig. 55) and the fourteenth were unequal in length and width, but both linear. The leaves of these two were longer than their stipules, but the slender apex is sometimes, at least, crumpled up beneath the apex of the stipule.

The larger of the two stipules of each leaf lies on the upper-

side of the branches or shoots bearing them. The leaves are all conduplicate in bud, acuminate, and penninerved, with closely approximate nerves in the bud. The two halves of the leaf are unequal, but this is scarcely discernible in bud. The broader half lies next the axis, as in the Lime.

The leaves of the Elm are in two ranks, and the scales follow the same plan.

Now if the stipules were not connate, they would be in *four* ranks as in the Beech, *two* ranks on each side of the stem, whereas there is actually only *one* rank on each side of the stem —that is, two ranks in all.

As the leaves come out the shoot curves down, and the stipules form arched hoods over the young leaves. They are often bright pink and very pretty.

Ulmus montana, With. (Wych Elm).—The exposed parts of the outer scales are dark brown, the covered portion much paler. They are, as a rule, more or less notched at the end. The inner ones pass gradually into pink, greyish green at the base. The young bud (Pl. **14**. fig. 1) is in a line with the branchlet, but as it expands it turns downwards and hangs at right angles to it (Pl. **14**. figs. 2, 3, 4). When the young shoot has reached the stage shown in fig. 3, any slight touch is sufficient to detach the outer scales. A few days later the pink scales also begin to wither and fall off. The leaves then rise up again and assume their permanent position.

Humulus Lupulus, Linn. (the Hop).—The stipules (fig. 56) are connate in one interpetiolar piece, each half of which belongs to different leaves of the pair at the node.

Ficus pumila, Linn. (syn. *F. repens*, hort.).—Leaves alternate and distichous on the juvenile form of the plant, obliquely cordate, obtuse, slightly scabrous, petiolate, stipulate. They change in the flowering stage of the plant, becoming very leathery and densely netted. The early stages are creeping, the flowering stage is self-supporting, as in *Hedera Helix*. Petiole short, terete, slightly grooved above, not dilated at the base, thinly pubescent.

Stipules linear, acuminate, free, inserted all round the axis, but wider than their base and overlapping one another, enclosing the terminal bud, pale green or colourless, soon becoming pale brown, persistent or very tardily deciduous. They remain erect, each being concave and enclosing about half of the stem.

The terminal bud is protected by each pair of stipules in succession.

The axillary buds are protected in their earlier stages by the persistent stipules.

Fig. 56.

Humulus Lupulus, ×3.

Pilea grandis, Wedd.—The stipules are cordate, obtuse, red at first, then pale green, tinted with red along the middle, membranous, colourless at the margins, sessile, and completely surrounding the axis, until the latter thickens considerably, intrapetiolar and connate, persisting for some time. They measure 1·2–1·4 cm. wide and 1·4–1·8 cm. long.

The terminal bud is covered by the stipules of the last developed pair of leaves; at this stage the stipules are nearly orbicular, erect, and face to face. The first or oldest pair of leaves enclosed by them are conduplicate, slightly interlocking by their edges or equitant, and occupy but a small portion of the space enclosed by the stipules.

The axillary buds lie inside the erect base of the stipules. They long remain quite small and more or less completely covered. They comparatively seldom elongate into shoots, the latter being relatively few to a plant.

Pilea muscosa, Lindl.—The terminal bud consists of a pair of

leaves, face to face, and covering all the younger members. They unfold when about half-grown, and meanwhile the next pair is of some size. The internodes are very short, so that two or three pairs come close up to the terminal bud and afford some shelter.

The axillary buds are developed in the axil of almost every leaf and sheltered in the groove on the face of the pedestal in their early stages.

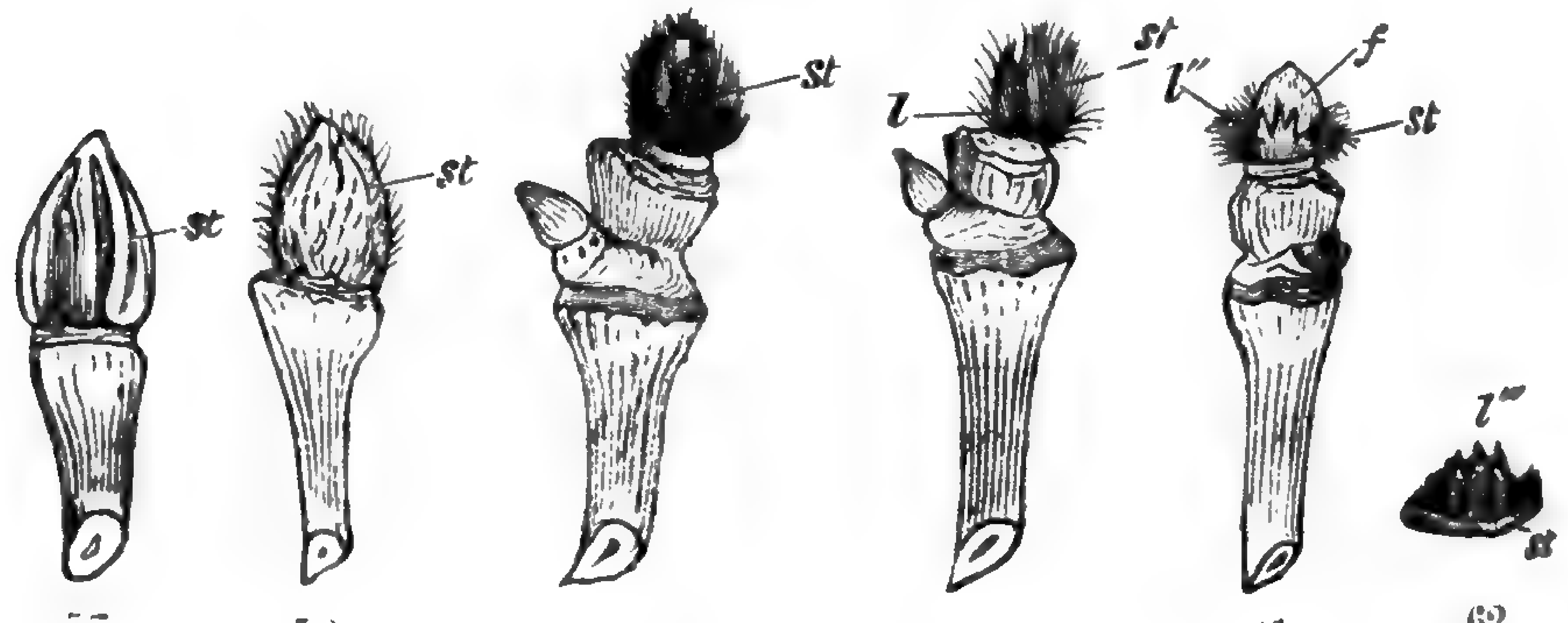
The plant is slender, of delicate texture, and evidently adapted for growing in moist shady places, where it would be naturally protected from radiation. The small size and crowded state of the leaves would seem to explain the absence of stipules, as they shelter one another. Those of *P. grandis* are probably 50–100 times larger.

PLATANACEÆ.

As an illustration of the careful and effectual protection of the young leaves in the bud, there is no better illustration than that of the Plane, *Platanus orientalis*, Linn.*

Fig. 57 represents the terminal bud of the leading shoots and

Figs. 57–62.



57 58 59 60 61 62

Platanus orientalis.

57. Winter-bud, nat. size ; *st*, outer or first stipular scale, entire.
58. *st*, second stipular scale, glandular and slightly hairy, entire.
59. *st*, third stipular scale, very hairy, with a minute opening at the apex.
60. *st*, fourth stipular scale, very hairy, open at the apex ; *l*, the first leaf.
61. *st*, fifth stipular scale, now much shorter than the bud and open at the top, showing an inflorescence, *f* ; *l''*, the second leaf, which is slightly five-lobed.
62. *st*, Sixth stipular sheath, now reduced to a narrow rim, hairy, and here spread open ; *l'''*, the third leaf, which is five-lobed, with the two small lobes folded on the back of the leaf.

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* Brief but excellent descriptions of the buds of this and the following species have been given by Henry, in Nov. Act. Nat. Cur. xviii. (1836) pp. 528–534.

also of the lateral spurs or short twiglets covered with a conical, ribbed, glabrous, red cap, consisting of stipules that are connate to the very apex; the latter is slightly lateral and all the ribs or veins terminate there.

Fig. 58. Inside the first comes a second cap, thinly hairy, dotted with dark glands and completely covered with a viscid, resinous secretion, the veins terminate at the apex.

Fig. 59. The third cap is also entire, but densely covered with glossy rich brown hairs; the latter have 3-6 very short, spreading branches at the very base, and consist of 2-6 joints, resembling a bamboo or fishing-rod, the joints becoming more slender towards the apex. The cap secretes a resinous substance which affords an additional protection.

Fig. 60. The fourth cap is shorter, widely open at the apex, and provided with an ovate leaf at its base externally; both cap and leaf covered with brown hairs.

Fig. 61. The fifth, sixth (fig. 62), seventh, and eighth, more or fewer, show a leaf with the free portion of the stipules forming auricles, and the connate portion forming a short cylindrical sheath.

Inside the above in all the large buds comes a spike of heads or clusters of fruits, the heads so arranged as to form a conical mass inside of the various caps and short cylinders formed by the stipules.

The mode of development of the woody fibres has been well described by Colomb (Ann. Sci. Nat., Bot. sér. VIII. vi. 1887, p. 56).

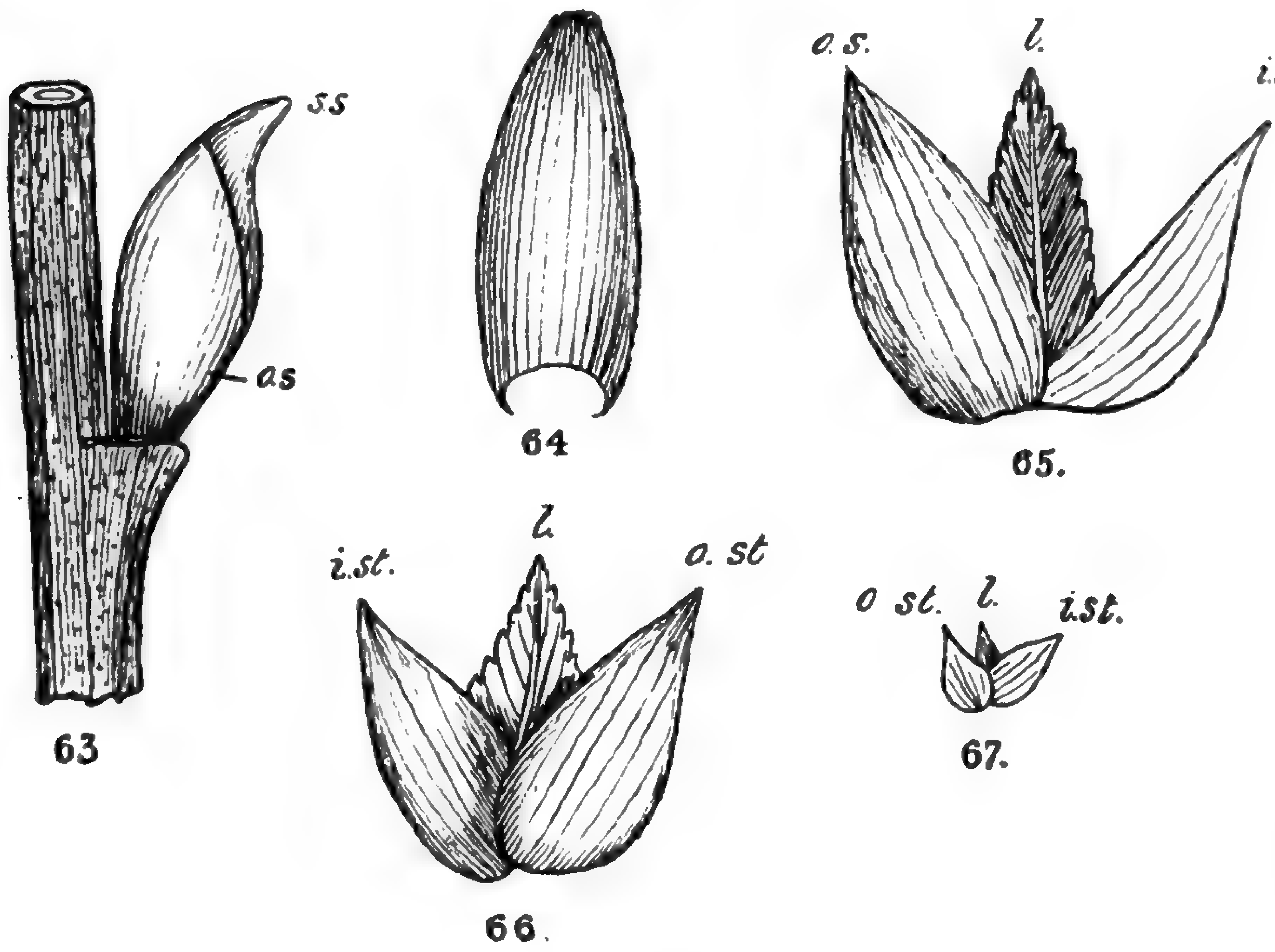
CUPULIFERÆ.

Alnus glutinosa, Medic.—The winter-buds of the common Alder are protected by stipules, the outer of which are more or less hardened or coriaceous and brown. The terminal bud is generally protected by two of these hardened scales, about equal in size. The lateral buds (fig. 63) are generally protected by an outer scale (fig. 64), which covers about three-fourths of the bud, and seems to consist of two stipules, inserted right and left of the fallen leaf of the main axis, and connate by the edges lying between the bud and the axis. Sometimes there are two outer scales to the lateral buds, particularly the shorter ones. These scales sometimes become emarginate or bifid during the expansion of the bud; and here again the shorter ones are most liable to rupture. The outer scales of the long buds are more or less denticulate at the apex, but seldom become fissured, as they offer

little hindrance to the expanding bud. The outer scale consists of a pair of connate stipules, not leaves.

The outer scale (fig. 64) has no leaf in connection with it.

Figs. 63–67.



Alnus glutinosa, ×3.

63. Portion of shoot bearing a lateral bud; *o.s*, outer scale; *s.s*, second scale, that is, the outer one of a pair of stipules.
64. Outer scale of winter-bud.
65. *o.s*, outer, and *i.s*, inner stipule of the first distinct pair; *l*, their leaf, flattened out like the stipules.
66. *o.st*, outer, and *i.st*, inner stipule of the second distinct pair; *l*, their leaf.
67. *o.st*, outer, and *i.st*, inner stipule of the third distinct pair; *l*, their leaf.

The second pair of stipules (fig. 65) of the more typical lateral buds are free, unequal, imbricate, and completely cover their own leaf and all the younger members of the bud. The outer stipule of this second pair is ovate, more or less exposed along the middle and at the apex, which is curved, the exposed portions being more coriaceous than the rest. The inner of the two is half-ovate, pale green, and membranous. Both are traversed longitudinally by slender parallel nerves. The leaf in connection with the second pair is lanceolate-oblong, acute, serrate, glandular, and plicate along the course of the ascending nerves. It is more or less folded over the younger members of the bud. All the leaves and stipules are glued together by a viscid, resinous, fragrant gum, secreted by glands.

The third pair of stipules (fig. 66) are slightly unequal, narrowly ovate or lanceolate, membranous, and more faintly nerved than the previous pair. The outer stipule envelops about two-thirds of the bud, including its fellow stipule and the leaf. The latter is ovate-elliptic and folded over the younger members of the bud as a rule. The fourth pair of stipules and their leaf (fig. 67) are sometimes very similar to the preceding set, sometimes very much smaller. This difference is apparently due to the relative vigour of the axis bearing them.

The descriptions and sketches were made from buds just bursting, about the middle of April.

Betula alba, Linn.—The winter-bud as it appears about the beginning of April is ovoid-oblong, obtuse, glabrous, or having a few cilia at the margins of the scales, and deep brown. The scales are in pairs, and consist really of stipules. The outer two or three pairs have no leaves, and one or two of the pairs are coriaceous.

The first pair are slightly unequal in length, and do not overlap at any point nor surround the whole of the bud, being situated partly on one side. The second pair, when partly spread out, are almost semiorbicular, rounded at the apex, and slightly unequal in length, the inner one being the longer and overlapped at the base by its fellow at both edges. They cover a considerable portion of the bud, owing to their width. The third pair are as long as the bud, covering the whole of the younger members and overlapping at their edges. They are more membranous than either of the one or two preceding pairs, and are more or less furnished with a viscid gum. They are also slightly narrowed at the base.

The fourth pair are more decidedly boat-shaped than the previous one, but are still imbricate.

The first leaf occurs in connection with the third or fourth pair of stipules, but entirely inside of and covered by them. It is rhomboid, acute, shortly petiolate, serrate, penni-nerved, with ascending nerves, thinly pubescent, glandular and viscid in bud, and concave.

The fifth pair are somewhat smaller than the fourth, but otherwise similar, as is their leaf. Its form is doubtless due to the abrupt arrest of the younger members of the bud; for the fourth and fifth pair of stipules, together with the first and second leaves belonging to them respectively, are greatly in advance of those that follow. The sixth pair of stipules and the younger

members of the bud they enclose will show a reason for the second leaf being partly involute, so as to occupy the space.

The terminal bud of adult trees, and generally one or two of the lateral ones close to it, consist of a few pairs of very small scales enclosing a male catkin, which bursts into growth weeks before the other buds. Below these the lateral buds are similar to that described, but they contain only two leaves as a rule, and a female catkin which terminates the axis of the bud. Lower down the same shoots we meet with leafy or wood-buds, in contradistinction to flower-buds. On other parts of the same tree, however, leafy buds may, and do, occur anywhere.

Fagus sylvatica, Linn.—The bud of the Beech (Pl. **15**; and figs. 68–78) is elongated, spindle-shaped, $\frac{1}{2}$–$\frac{3}{4}$ inch in length; on the outside are eight closely imbricating rows of stipules arranged apparently in opposite decussate pairs. I say apparently, because, as the leaves are alternate, it is possible that these stipules are really alternate, though so compressed as to appear to be opposite.

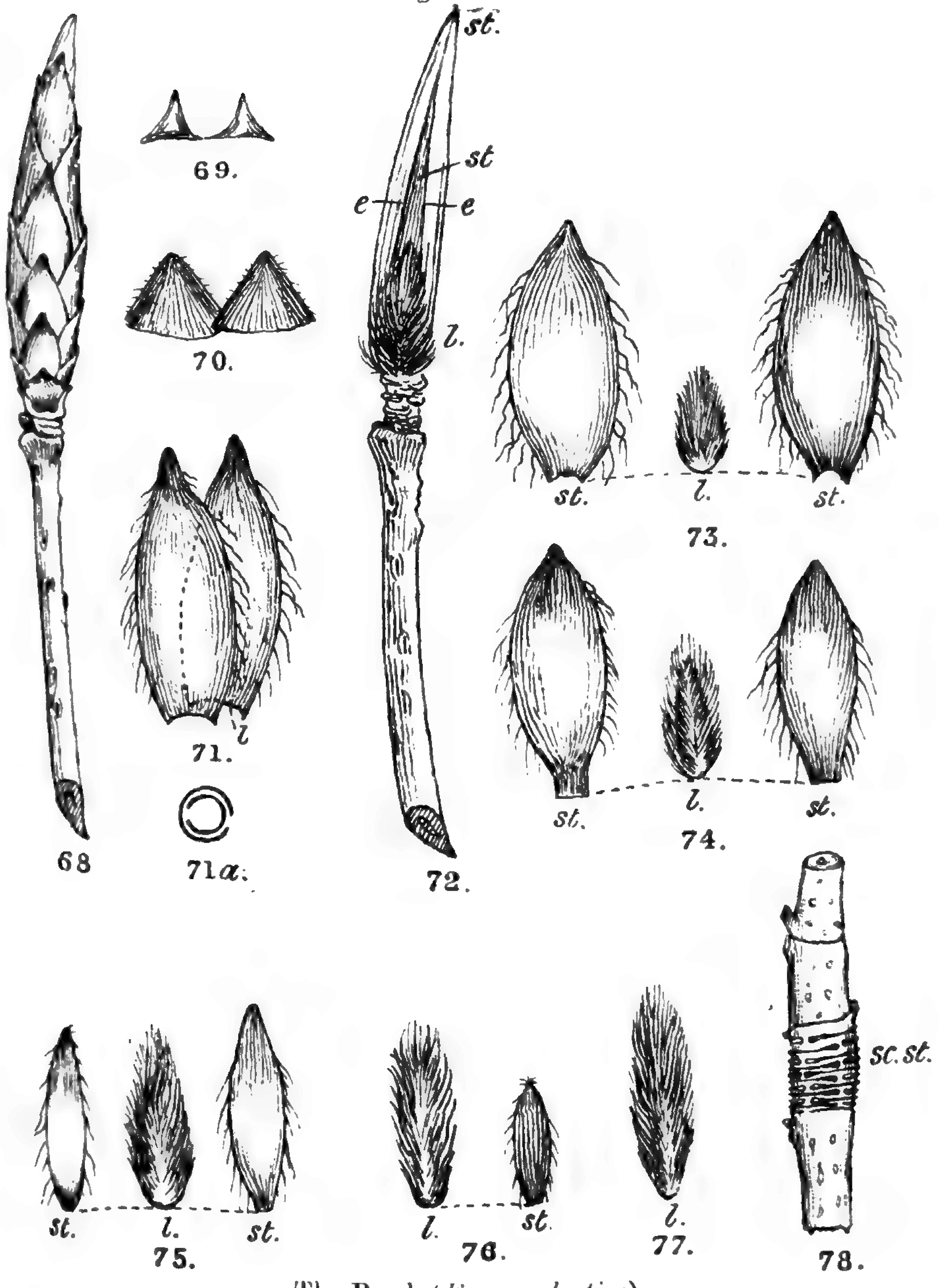
The first pair (fig. 69) are small, triangular, and pointed. The five following are also triangular, each rather larger than the preceding and more convolute, till each almost encloses the whole upper part of the bud. The lower ones are brown and coriaceous; the upper membranous, and furnished with numerous straight, longitudinal, parallel, slender veins from the base to the apex. The covered parts are white, the exposed brown. The upper ones are ciliated with long, recurved, silvery or satiny hairs. They are sometimes a brilliant pink or rose-colour, but less often than those of the Hornbeam. The fifth and sixth pairs (fig. 70) are ciliate with short hairs, and rolled round a considerable part of the bud.

The seventh pair are half as long as the bud, but otherwise like the sixth; the eighth pair two-thirds as long as the bud; the ninth nearly as long as the bud, with silky hairs directed downwards, and the outer one of the two distinctly overlaps the inner. The tenth pair are as long as the bud and each is convolute, so as to cover nine-tenths of the bud or even more. The eleventh pair (fig. 71) are similar, and almost meet at their edges. These eleven pairs of stipules show no traces of a leaf.

Fig. 72 represents a bud after the removal of the first eleven pairs of stipules.

About the twelfth pair there is a material change; they (fig. 73)

Figs. 68–78.



The Beech (*Fagus sylvatica*).

68. Winter-bud.
69. First or lowest pair of stipules.
70. Sixth pair of stipules overlapping at the corners.
71. Eleventh pair of stipules, showing how one is rolled within the other; *l*, position where the leaf should be though it is yet absent; 71 *a*, transverse section of the stipules, showing the extent to which they overlap.
72. The bud after eleven pairs of stipules have been removed; *l*, the first leaf; *st*, *st*. the twelfth pair of stipules; *e*, *e*, the edges of the outer one of the twelfth pair.
73. *st*, *st*, the twelfth pair of stipules flattened out; *l*, the first leaf belonging to the same.
74. *st*, *st*, the thirteenth pair of stipules; *l*, the second leaf.
75. *st*, *st*, the fourteenth pair of stipules; *l*, the third leaf.
76. *st*, the only stipule of the fifteenth pair discernible in this bud; *l*, the fourth leaf.
77. No stipule discernible in the bud examined; *l*, the fifth and last leaf discernible, occupying the centre of the bud.
78. Junction of the wood of two seasons' growth; *sc.st.*, scars of the outer eleven pairs of stipules that covered the winter-bud and which were unaccompanied by leaves.

are smaller and have a leaf; this is about one-third as long as its stipules, concave on the inner face, and plicate along the course of the ascending lateral nerves.

The thirteenth pair of stipules (fig. 74) are rather narrower, especially at the base. The leaf is about half as long as the stipules.

The fourteenth pair (fig. 75) are much smaller, thinner, narrower, and unequal; the inner one being the smaller. The leaf is three-fourths as long as its stipules.

The leaf (fig. 76) belonging to the fifteenth pair was longer and more bulky than the stipule.

The next leaf (fig. 77) is large, deeply concave, or rolled into a cylinder, occupying the centre of the bud, and densely covered with silky hairs on both surfaces, but particularly on the back, as are all the others.

The above description may be regarded as giving the average composition of the winter or resting bud of the Beech. Larger buds have a greater number of leaves and stipules; smaller buds fewer. Stronger shoots on vigorous young trees have more leaves, though the inner ones are very small or but slightly developed in winter.

If the shoot is examined the scars where the stipules were inserted may be seen, forming rings (figs. 78, 79) round the base of each annual shoot. The shoot elongates considerably between the leaves, but not between the stipules, so that the stipular rings remain close together; these are very persistent, and can be traced for years.

The long, narrow, brown stipules of the bud are thrown off when the leaves expand, and may be found in large numbers under the trees. The terminal bud is straight; the lower ones stand out from and curve towards the twig. Before unfolding they tend to turn upwards, but afterwards bend down (Pl. 15. figs. 2–6), as in the Elm &c. The leaves are plicate.

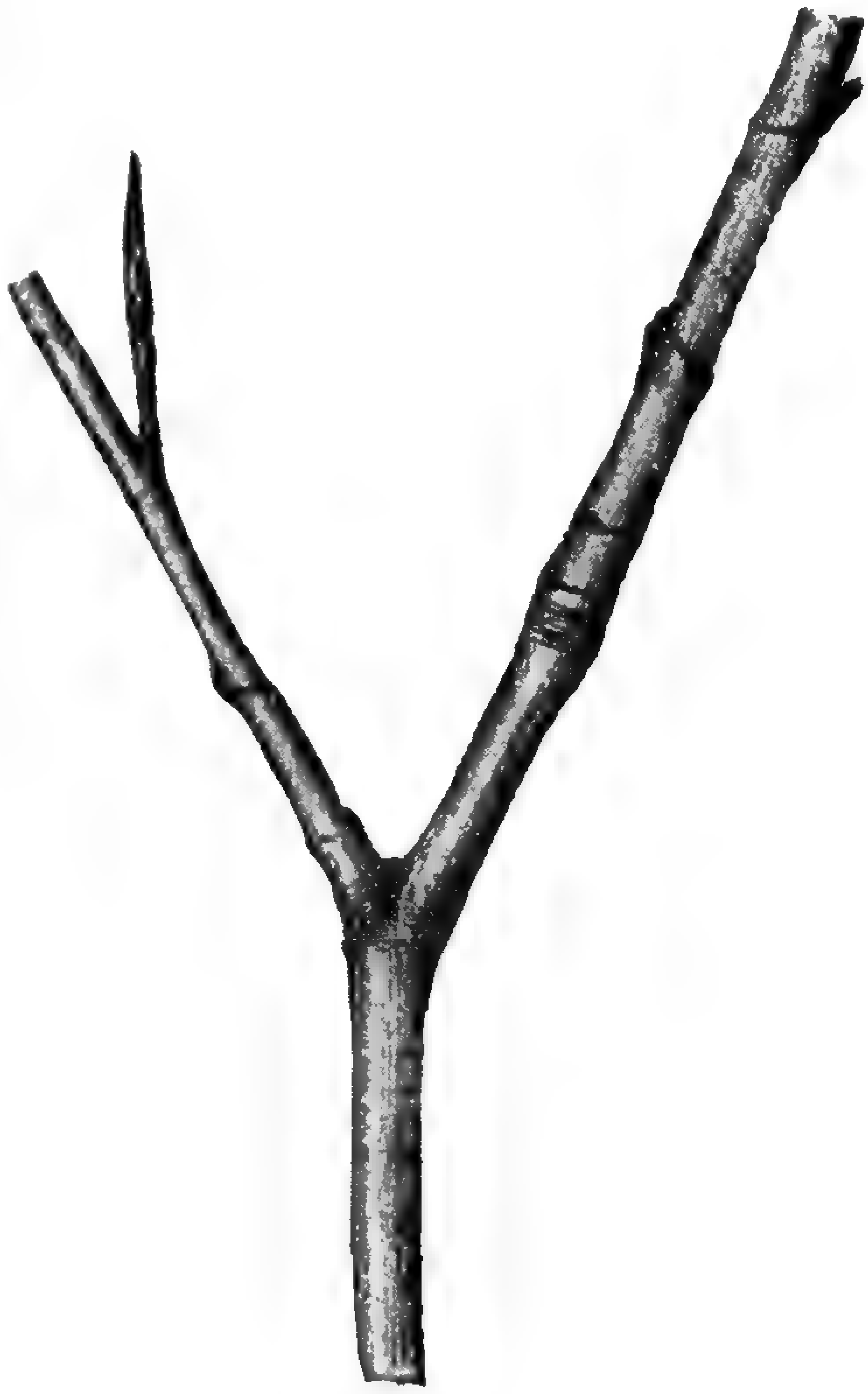
The flowering-buds (Pl. 15. fig. 7) are much thicker than the others.

Carpinus Betulus, Linn. (Pl. 12. figs. 4 & 5).—The bud of the Hornbeam has at the base about half a dozen* very small dark scales, then two, pale at the base and brown above, rounded at the apex, and sometimes with two points, then two or three coloured like the preceding, but pointed; then follows the pair enclosing the first leaf. After these the stipules become longer,

* I could not determine the exact number, as two or three had fallen.

more hairy, and more rounded at the end, the brown part becomes shorter, and after one or two days disappears altogether; they are fringed with hairs. As the stipules expand the shoot turns down, so that the leaves hang towards the ground.

Figs. 79 & 80.



79. Twig of Beech.

80. *Corylus Avellana*, × 2.

Corylus Avellana, Linn.—The bud of the Hazel-nut (fig. 80) is protected by stipules which gradually increase in size. The first four pairs are without leaves. The fifth have a well-formed leaf. The second pair and following stipules are fringed with fine hairs round the edge. The stem and petioles have two kinds of hairs:—1, fine, silky, white, and more or less adpressed; and 2, reddish, upright, glandular, hairs. The young shoot bends over downwards for protection from cold. The leaves are conduplicate. The stipules are often beautifully pink.

Castanea vesca, Gaertn. (Spanish Chestnut).—The scales which protect the bud of the Spanish Chestnut (figs. 81 & 82) are, I believe, connate stipules; this is indicated by their being frequently indented at the apex. The outer one is dry and brown. The second scale is longer and greener. Its true character is shown not only by the indentation at the summit, but by the

presence of a rudimentary bud at the base, which is situated, not at the side as it would be if the scale were a single stipule, but (fig. 82) opposite the centre.

Figs. 81 & 82.

×4.

$1\frac{1}{2}$ nat. size.

Spanish Chestnut.

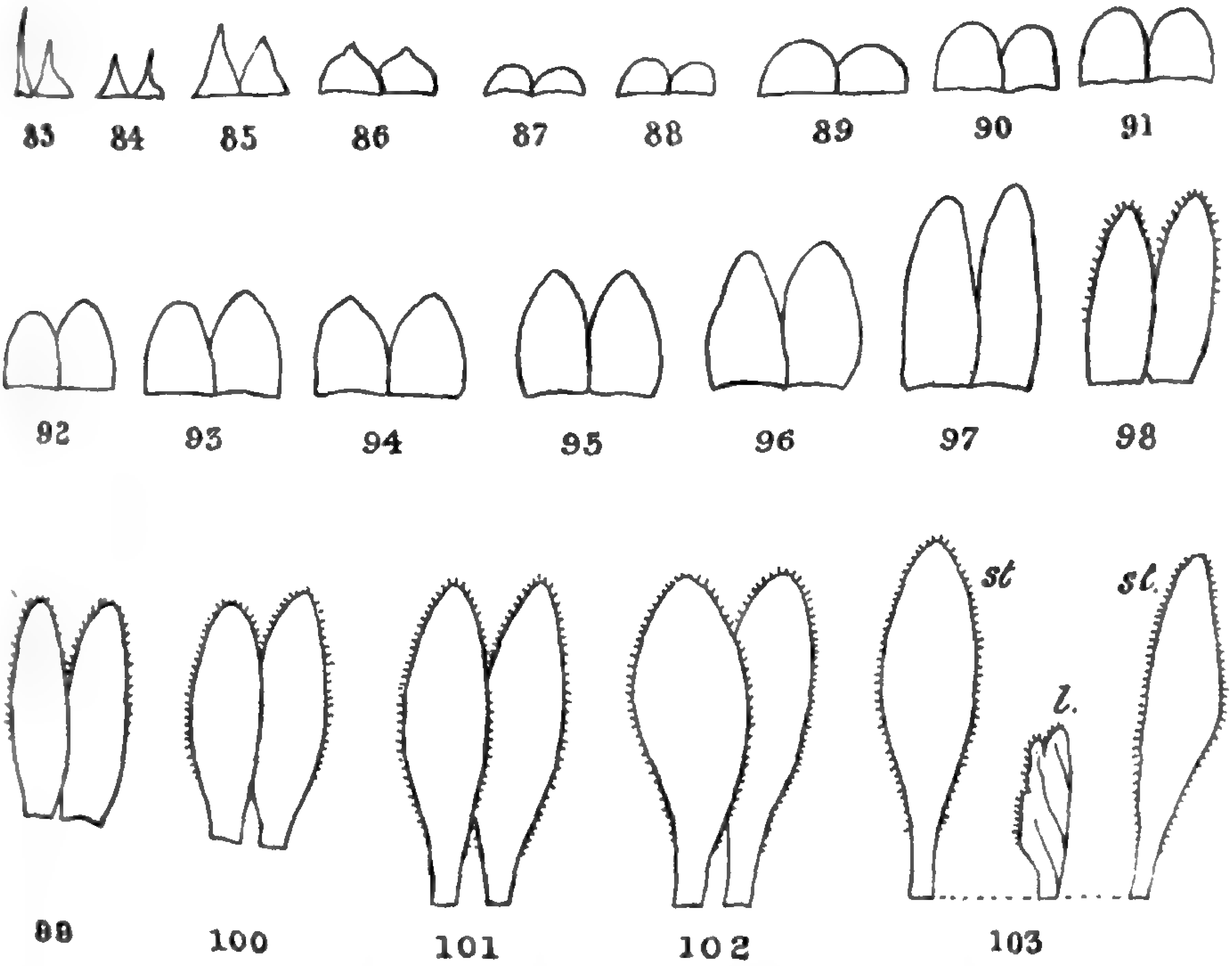
The following pairs are separate, hairy, and about as long as their leaf. The next leaf and its stipules are similar. The fifth pair of stipules are narrower and rather shorter than their leaf. The following stipules become quite narrow. The leaves are conduplicate.

Oak, *Quercus pedunculata,* Ehrh.—The buds of the Oak are even more complicated than those already described; they (figs. 104 & 105) are a rich brown, and make a beautiful contrast with the greyish-black of the stems. They are short and conical and the colour, together with the arrangement of the scales, gives them a curious similarity to a miniature cone of a pine.

The buds differ considerably in size, but are comparatively short, broadest above the base but somewhat below the middle, covered with dry brown stipules, arranged in five imbricating

rows. The buds are slightly pentangular, each of the five angles being made up of one stipule from each of two continuous and successive pairs. The pentangular character of the bud is due to the leaves being on the $\frac{2}{5}$ plan of arrangement.

Figs. 83–103.



Quercus pedunculata.

83–102. Pairs of stipules forming the scales of the winter-bud, sketched in the first week of May; some of them had small lateral buds between them, but no leaf; the bud had resumed growth, was oblong, and 16·5 mm. in length.

103. ×2. *st*, stipules; *l*, leaf, conduplicate in bud, but not likely to attain any great size if it had been allowed to develop.

97–103. Stipules which had elongated when growth was resumed in spring.

N.B. The bud sketched was a large lateral one, and the leaves would be aggregated at the apex of the shoot when the latter is full-grown.

The first two pairs (figs. 83 & 84) have a slender point, which is often broken off in winter. The next two are also pointed; the next ones are rounded and short; those following more and more elongated, and ovate, membranous except at the base, strongly ciliate or hairy at the margins, and densely hairy at the base on the inner face. The number of leafless stipules differs in different buds, but there are sometimes more than 40, or 20 pairs, before those containing the first leaf. Figs. 83–103 represent the series in a single bud. The first leaves are small, and often bent and

crumpled from not having room to extend either longitudinally or laterally. They are obovate, very shortly petiolate, with two and three or three and four lateral lobes, with a terminal one, and are greenish yellow, glabrous with the exception of a few hairs on the midrib, especially on the underside, with a few small ones at the edges of the lobes beneath. They are accommodated in the middle line between the angles formed by

Figs. 104 & 105.

Oak buds.

the stipules and by the thinning away of the edges of the latter; and the lobes seem to favour their being crumpled laterally or crushed together at the sides, as they have most room along the middle line.

The hairs at the edges of the stipules serve to keep the buds compact, and to drain away moisture down the outside of the same. The hairs at their base internally would fill up the space where the leaves become narrowed towards the petiole, and would also serve to keep the young and tender leaves warm.

Lateral and secondary buds occur frequently in the lower part

of the primary bud, in positions corresponding to the axils of primary but aborted leaves. They have the same structure as the primary ones, but are much simpler, and consist of a few pairs of stipules, the outer ones of which are comparatively large. These buds appear but seldom to become developed into branches on the expansion of the primary bud, but remain small. Accidents to the primary bud, however, would of course cause them to become developed into branches.

The following is the composition of a flower-bud, that is, one containing amenta :—

The first fourteen pairs of stipules, or thereabouts, have neither leaves nor amenta, but serve the purpose of protection.

The first five pairs of stipules are very small and rounded; the first pair are often acuminate or tailed.

The sixth and seventh pairs are twice as large, roundly triangular, concave, finely ciliate.

The eighth and ninth pairs are half the length of the bud, triangular, obtuse.

The tenth pair are $\frac{3}{4}$ the length of the bud, broadly triangular, subacute, covering great part of the bud, and pubescent on the back.

The eleventh and twelfth pairs are as long as the bud, and covering $\frac{3}{5}$ of it, each stipule covering two faces of it, and the half of one stipule overlapping half of the other. The cilia are now much longer than those of the previous stipules.

The thirteenth and fourteenth pairs are pubescent on both faces.

The fifteenth and sixteenth pairs cover a small, subcompressed, hairy amentum of male flowers. The amentum is axillary, but no leaf is discernible.

The seventeenth, eighteenth, and nineteenth pairs are much smaller than the two previous pairs, but otherwise similar, and each pair protect an amentum.

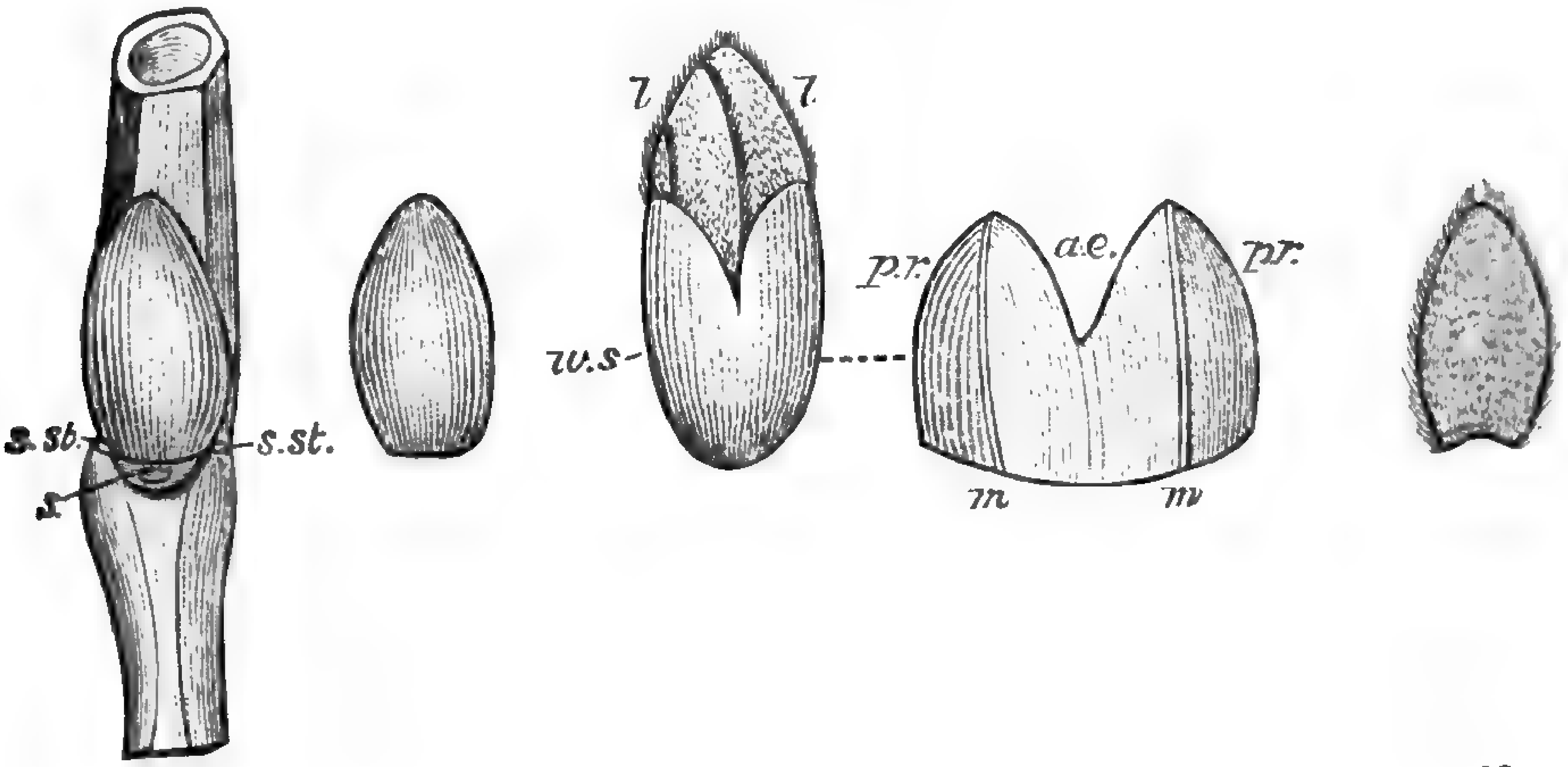
The twentieth pair are small, membranous, silky on both faces, covering a male amentum; and the twenty-first pair cover what appears to be a female inflorescence in a very minute or early stage of development. In all these cases, leaves are entirely absent or indiscernible during the months of winter.

In the Evergreen Oak the leafless scales are comparatively few. As the tree belongs to milder climates, perhaps the leaves do not require so much protection.

SALICINEÆ.

Salix Caprea, Linn.—The winter-buds of the Goat Willow are ovate, obtuse, tumid, relatively short, and more or less downy. The terminal bud dies, so that growth is renewed by the lateral ones (fig. 106). The bud is covered by a cap or scale in one piece

Figs. 106–108.



106. 106 *a*. 107. 107 *a*. 108.

Salix Caprea.

106. Portion of shoot with a lateral bud; *s*, scar of fallen leaf; *s.st*, scar of fallen stipules. 106 *a*. Posterior view of the same bud.

107. Anterior view of another bud bursting, showing the silky leaves, *l l*; *w.s*, winter-scale. 107 *a*. Anterior view of the same scale removed and spread out, showing two midribs, *m m*; *ae*, anterior edges, slit naturally; *p.r*, posterior edges, slit to the base naturally on the bursting of the bud.

108. The first leaf from the bud, 106.

that shows no line of cohesion on either the anterior (fig. 106) or posterior face (fig. 106 *a*). Laterally, however, there is a strong rib or keel, one on each edge. When growth recommences in spring, the scale splits regularly from apex to base on the posterior face, and from the apex downwards, for one-third to one-half its length, on the anterior face (fig. 107). If the scale splits further on the anterior face, it does so irregularly. The whole scale, flattened out at fig. 107 *a*, shows the extent of the natural splitting, and also the two ribs or keels. This method of splitting and the two ribs indicate that the scale of the winter-bud is composed of two leaves inserted right and left on the axis and cohering by their anterior and posterior edges. The first true leaf (fig. 108) is roundly ovate, obtuse, densely silky on the back and edges, and thinly hairy on the inner face. The second and third leaves are oval-oblong, obtuse, and narrower.

The fourth leaf is oblong and more narrowed to the base. The fifth leaf is lanceolate; and the sixth and seventh are very similar. The eighth leaf is more decidedly narrowed to the base, and when *in situ* is more completely rolled round the bud than the previous ones, and almost entirely covering it. It will be seen that there is little difference between the lengths of the first eight leaves. The ninth, tenth, and eleventh leaves are very similar to the eighth, but much shorter and smaller. The stipules are large, particularly on the leafy shoots; but they develop after the leaves are expanded, or during that process. Some forms are exstipulate.

In *Salix cinerea*, Linn., the winter-buds are ovoid, short, ancipitous or strongly but obtusely carinate laterally, that is right and left. The scale has a slight ridge along the centre of the posterior aspect, and this splits to the base as the buds expand in spring. The anterior face becomes notched or merely emarginate at the same period. The stipules are minute and inconspicuous in bud, but ultimately develop to large size.

S. pyrifolia, Anders., has the winter-buds short, ovoid, dorsally compressed, but biconvex, carinate on the two lateral edges, not ridged on the posterior face. The scale splits along the posterior face, but not always to the base. The anterior face splits about halfway down. The scale splits more than halfway down the dorsal aspect, then it splits circumferentially by a fairly even line till the upper portion is only held by a narrow shred, and in this position it clings to the axis for some time. The lower portion forms a cylinder round the axis, but is burst at last by the swelling of the latter, and the whole scale in this torn condition falls away. The leaves are oval in bud, densely woolly on the back and downy on the face.

S. cordata, Muhl.—Winter-buds relatively long, narrow, subulate, obtuse, obtusely carinate laterally, with a wide, shallow groove along the dorsal aspect. The scale splits to the base on the dorsal aspect, but merely becomes emarginate on the anterior face, and in this condition soon falls away bodily. The inner face of the scale often splits away from the outer, and appears like an inner very membranous scale. The stipules are very small in bud, but develop to fair size as growth proceeds. The larger ones are more or less cordate or half-cordate, and glandular dentate or denticulate.

Salix lucida, Muhl.—Winter-buds oblong, or the lower and shorter ones ovoid, very obtuse, tumid, strongly but obtusely carinate laterally, reddish-yellow, glabrous and shining as if varnished, as are the shoots. The scale splits to the base on the posterior face, which is convex; but the anterior face remains entire, in this respect resembling the scale of *S. alba*. The inner face splits away from the outer like a second membranous scale, when the bud bursts, as in *S. cordata*; it is likewise emarginate. A few of the lower leaves next the scale are furnished with long hairs, chiefly on the midrib, but the others are glabrous or nearly so. The stipules are small in bud, but afterwards become orbicular, or half cordate, higher up the axis.

S. lanata, Linn.—Buds large, ovoid, narrowed to an obtuse point, thinly woolly, light reddish-brown, not carinate, or only obtusely and obscurely so towards the apex. Winter-scale bursting to the base on the posterior face, and bidentate at the apex on the anterior face. The two principal nerves occupy a median lateral position, but approach towards the apex and end in the teeth. The inner face of the scale becomes almost completely separated from the coriaceous outer one, and elongates slightly with the developing bud; it is bidentate, and corresponds to the outer one except in texture.

The leaves are short, broad, ovate, varying to lanceolate higher up the axis, and densely woolly on both surfaces. The stipules are relatively large and ovate, but develop *pari passu* with the leaves, and occupy the space where the leaves are narrowed at the base. They are to a great extent covered by their own leaves, and are nearly glabrous in their earlier stages.

S. reticulata, Linn.—Buds ovoid, very obtusely carinate laterally. Winter-scale elongating considerably in spring, membranous, bursting a little more than halfway down on the dorsal face and bi-trifid at the apex anteriorly. The bud pushes out at the apex of this cylinder, but the scale eventually gets split and thrown off.

The leaves vary from orbicular to orbicular-oblong, strongly reticulate on both surfaces, thinly woolly when young, but becoming more nearly glabrous later on. The 'Student's Flora of the British Islands' says the species is exstipulate, but small tooth-like stipules are certainly present in spring.

Salix stipularis, Sm.—Buds lanceolate or narrowly ovoid, obtusely and faintly carinate laterally. Winter-scale bursting to the base posteriorly, and slightly bifid at the apex anteriorly. Leaves broadly lanceolate. Stipules linear-lanceolate, very small in bud.

S. phylicifolia, Linn., var. *Weigeliana*, Willd.—Buds ovoid, or oblong, more or less flattened, strongly carinate laterally. Winter-scale usually bursting to the base posteriorly, and varying from emarginate to bifid anteriorly. Many of the scales burst throughout their length on the anterior face, but such scales are generally crippled or dead, and often contain the grub of a moth. The leaves are also crippled, and have a difficulty in getting clear of the scale. Stipules small, and involute at the edges long after leaving the bud. Some of the scales burst at the apex and some at the base, but all appear to be crippled by insects or otherwise.

S. alba, Linn.—The winter-buds of the White Willow are all axillary; the terminal one as well as the tip of every shoot dies. The buds are oblong, obtuse or subacute, compressed antero-posteriorly, but tumid on the anterior face (fig. 109), thickened at the edges, and have a thickened suture (fig. 109 *a*) along the middle of the posterior aspect. The cap-like outer and only scale, owing to its thickened edges, might seem to consist of two leaves united, and the strong, slightly branched nerve easily seen on the inner face of these thickened edges tends to support this view; but no suture is discernible on the anterior face. When growth recommences in spring, the scale bursts along the suture on the posterior face (fig. 109 *b*).

When the tip of the scale dies in winter, it breaks off during the bursting of the bud; and when the whole of it dies the growing leaves rupture it at its insertion on the stem.

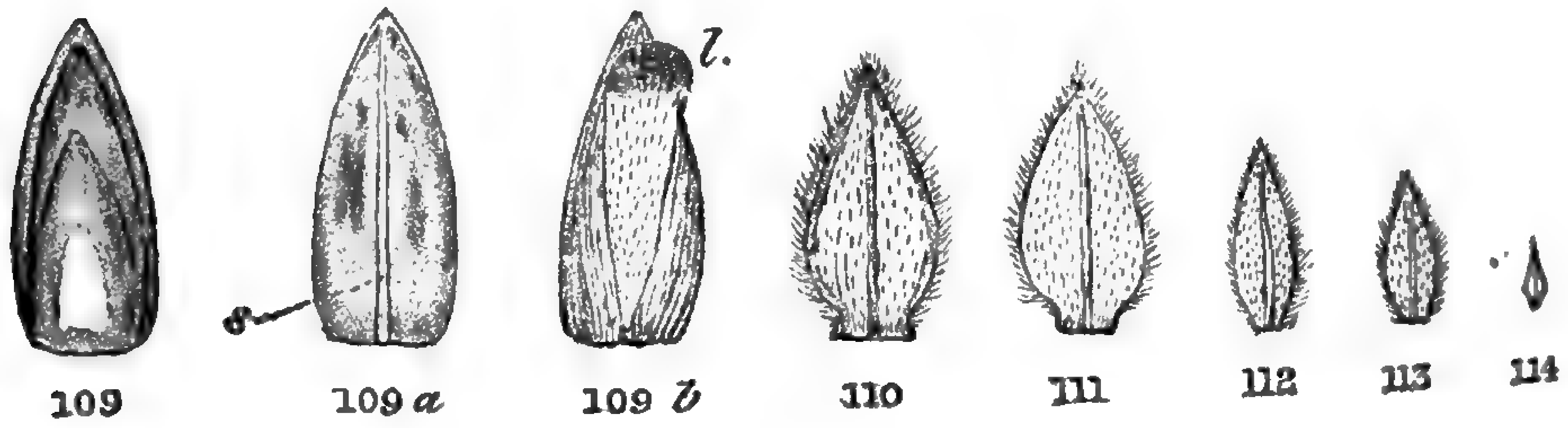
The first true leaf (fig. 110) is ovate, flattened on the posterior face against the axis, incurved at the sides, and covering two-thirds of the bud. The dorsal face is silky, but the inner is glabrous; edges ciliate.

The second leaf (fig. 111) is oblong-ovate, densely silky on the back, densely and finely ciliate.

The third leaf is smaller, and covers about $\frac{3}{4}$ of the bud, but otherwise is similar. The fourth is smaller, but covers about $\frac{7}{8}$ of the bud.

The fifth leaf (fig. 112) is lanceolate and very much smaller, but otherwise similar to previous ones. The sixth leaf covers the bud with the exception of a small slit at the base; but the seventh overlaps at its edges, completely enclosing the bud. The eighth leaf (fig. 113) is very small and membranous. The ninth

Figs. 109–114.



Willow (*Salix alba*).

109. Anterior aspect of winter-bud covered with one scale. 109 *a*. Posterior aspect of the same, showing the median thickened suture, *s*. 109 *b*. Scales of winter-buds bursting along the suture on the posterior aspect, showing the mass of leaves *l*, bent at the apex.
110. The first true leaf immediately inside the winter-scale.
111. The second leaf.
112. The fifth leaf.
113. The eighth leaf.
114. The tenth leaf.

leaf is membranous and almost glabrous; while the tenth (fig. 114) is lanceolate, acuminate, subtransparent, glabrous, and minute. All these smaller leaves are completely convolute, and they gradually open at the edges as the younger members of the bud become more bulky.

The stipules are minute or undeveloped in the winter-buds. The convolute vernation of the leaves, and their silky, densely ciliate character amply protect the younger members. The bursting of the winter-scale along the posterior face allows it to prolong its period of protection.

Summary of the Winter-buds of Salix.

I have been in some doubt with respect to the nature of the scale covering the winter-buds, but have come to the conclusion that this scale consists of two modified leaves, connate by their margins along the median line of the posterior and anterior aspect of the bud respectively, and advance the following reasons:—

1. The scale in all the 11 species bursts along the posterior face, generally to the base. *Salix pyrifolia* and *S. reticulata* are exceptions, inasmuch as they generally split a little more than

halfway down. The swelling of the axis completes this operation later on. *Salix phylicifolia* var. *Weigeliana* often bursts along the anterior face, or irregularly; but this appears to be due to the crippling of the bud by parasitic insects.

2. There is sometimes a ridge on the posterior face corresponding to the line of union, as in *S. alba* and *S. cinerea*. In *S. cordata* there is a wide shallow groove at the same place.

3. The anterior face during the expansion of the buds in spring becomes emarginate, bidentate or more or less deeply bifid at the upper end. *S. alba* and *S. lucida* are exceptions, inasmuch as the anterior face remains entire. I have observed no ridge, indicating union, on the anterior face; but as this is generally absent or inconspicuous on the posterior face, it does not much invalidate the presumed cohesion of the anterior edges of the leaves.

4. The strongest evidence, perhaps, of the presence of two leaves in the formation of the winter-scale, is that the latter is more or less strongly carinate on the edges, right and left, that is laterally. *S. lunata*, *S. reticulata*, and *S. stipularis* are obscurely carinate. The inner face shows a number of longitudinal, parallel nerves, the two strongest of which occupy the position of the carina or keel, and correspond to the midribs of the two leaves. The midribs being right and left of the bud, agree with the insertion of the first two leaves of axillary buds, those leaves being generally at right angles to the leaf on the main axis.

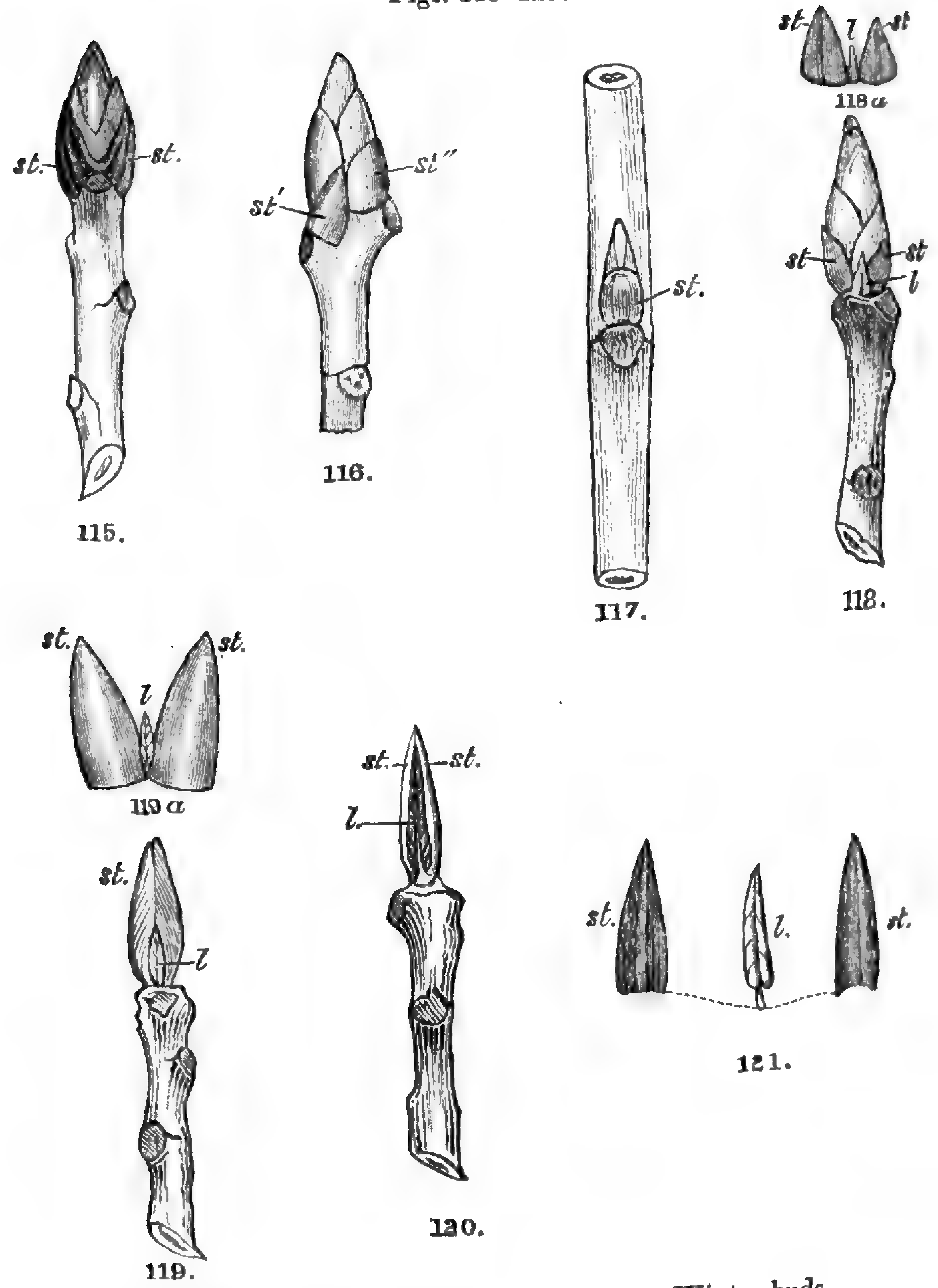
A curious case occurs in *Salix cordata*, *S. lucida*, and *S. lanata*. The inner and membranous face of the scale separates more or less completely from the coriaceous outer one, and resembles a second scale. It is, however, exactly opposite to the outer layer of the scale (not alternate), and is divided in the same way as the outer layer.

Populus nigra, Linn., var. *pyramidalis*, Spach (fig. 115).—The terminal bud of the Lombardy Poplar is conical, angular, and 3·5–7 mm. in length. Axillary or lateral buds are smaller and much less angular, owing to the fewer scales in their composition.

Sometimes one or both of the stipules of two fallen leaves, not forming part of the terminal bud, persist through the winter.

The first and second pairs of stipules forming part of the terminal bud belong to leaves that developed during the previous summer and fell in autumn. They are the hardest of the stipules, because dead. The third pair are larger, and to them belongs the first leaf of the bud. The fourth pair are longer than the

Figs. 115–121.



Populus nigra, var. *pyramidalis*, ×2. Winter-buds.

115. Terminal bud showing one pair of persistent stipules, *st st*, belonging to a leaf of the previous season.

116. Terminal bud showing one from each of two pairs of persistent stipules, *st′*, *st″*.

117. Axillary bud showing only one of the outer pair of stipules, *st*.

118. *l*, third leaf in the bud, often dying in winter; *st*, *st*, its stipules shown separate.

119. *l*, fifth leaf in the bud; *st*, *st*, its stipules. 119 *a*. The same, shown separately.

120. *l*, eighth leaf in the bud; *st*, *st*, its stipules.

121. *l*, inner face of eighth leaf; *st*, *st*, its stipules spread out.

third. Their leaf is subulate, and about one-third as long as their stipules. Sometimes it dies in winter. The fifth pair are sometimes, though not always, as long as the bud. The third leaf belongs to them, and has increased considerably in size and slightly in length. The sixth pair, because covered by the previous ones, are more membranous. The fourth leaf, belonging here, is nearly as long as the stipules. The seventh pair are about half the length of their leaf, and very membranous. The ninth and tenth pairs are less than half the length of their leaf.

The above would be the average composition of a bud at mid-winter; but there is considerable variation in the relative lengths of the leaves and their stipules. Sometimes the third leaf belonging to the fifth pair of stipules is nearly equal in length to the latter; but it may be the fourth, fifth, or sixth leaf which attains this size. The first two or three leaves never attain any great size, even if they live through the winter. Their stipules, however, are always largely developed, and more or less cemented together with a viscid gum, obviously for the protection of the leaves. The leaves that attain a large size in the bud retain their predominance after expansion, while the small outer ones remain relatively small.

The axillary or lateral buds are small, and covered by two pairs of large stipules, the rest being smaller. The leaves accompanying the latter, however, are relatively large.

CONIFERÆ.

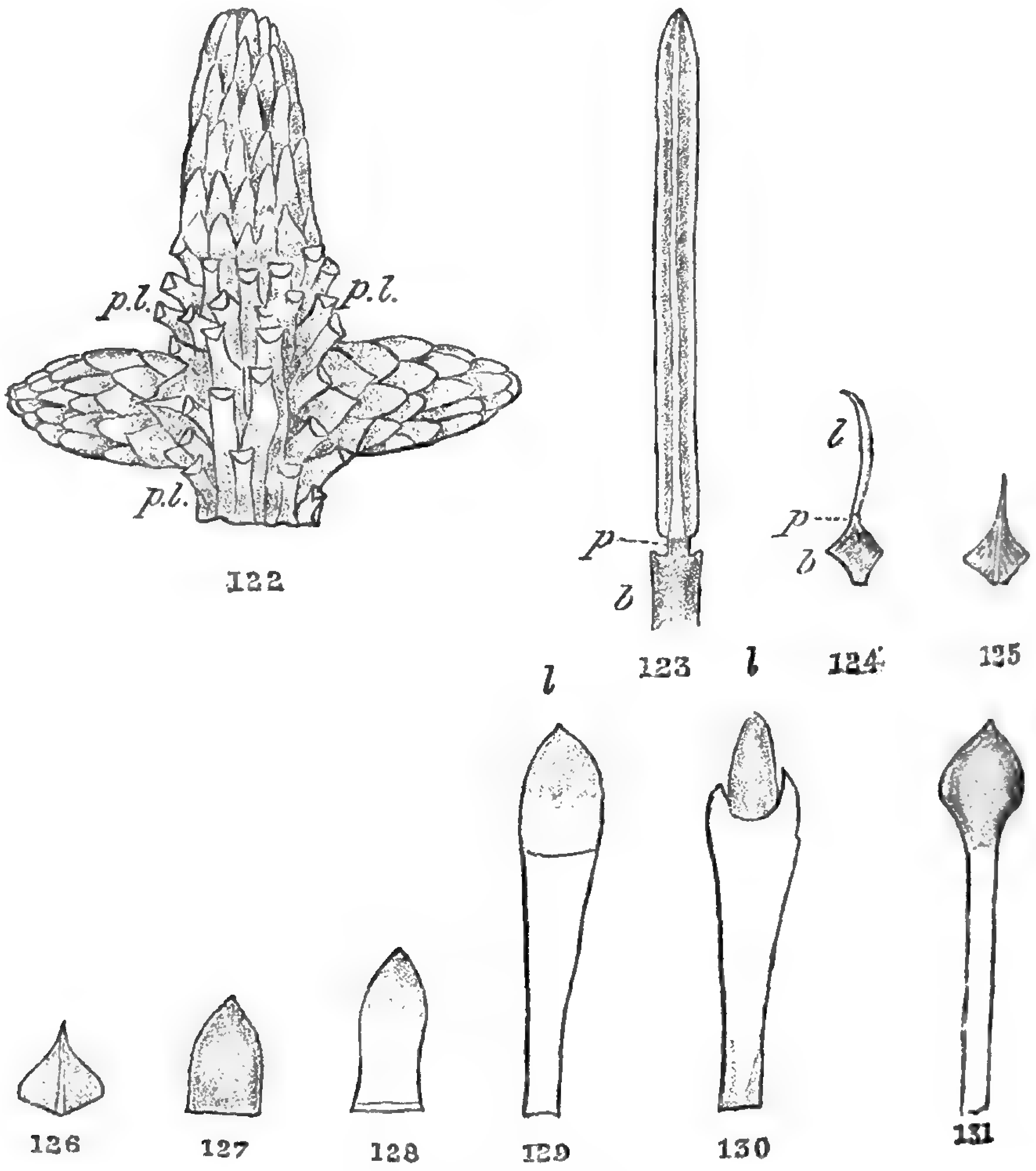
Picea excelsa, Link.—The winter-buds (fig. 122) vary greatly in size, those at the apex and immediately beneath it being strongest on the leading branches; they are also the first to resume growth in spring. All are covered with numerous scales, which consist of modified leaves. The actual number of scales varies greatly according to the size of the bud. The accompanying figures would represent buds and scales about the middle of April, after growth has recommenced. The outer scales are the most coriaceous, and elongate slightly or not at all; the inner ones are transparent and membranous, elongating considerably in spring.

The true leaf (fig. 123) consists of a lamina, which becomes disarticulated (when about to fall) from a short persistent portion or pedestal, surmounting a basal portion which is decurrent upon

the axis. Fig. 124 shows a small, slightly modified leaf—a form which occurs but sparingly.

The basal portion of the bud is covered with broad, triangular, acuminate scales (figs. 125, 126) with a more or less evident

Figs. 122-131.



Picea excelsa, ×3.

122. Apical and two lateral buds; *p.l*, *p.l*, *p.l*, pedestals of leaves after the green portion has been removed.

123. Normal and perfect leaf; *l*, leaf; *p*, pedestal; *b*, basal portion decurrent upon the axis.

124. Slightly modified small leaf; *l*, leaf; *p* and *b*, pedestal and base merged in one another.

125 & 126. Leaves now modified to triangular acuminate scales with a midrib.

127 & 128. Succeeding forms of scales.

129, 130, & 131. Inner scales after they have elongated, about the middle of April; *l*, *l* in figs. 129 & 130 would seem to represent the lamina, surmounting elongated pedestals; the same portion in fig. 131 is hooded over the apex of the bud; the lower portions are membranous and transparent.

midrib, and which seem to consist of the whole leaf modified. These are followed by a few oblong, obtuse, or subacute scales (figs. 127 and 128) that are still coriaceous, but elongate slightly in spring in the case of the inner ones.

The innermost scales (figs. 129, 130, and 131) are as long as the bud, or nearly so; but after the resumption of growth they soon extend beyond the coriaceous ones, keeping pace for a time with the elongating axis, and completely enclosing the young and true leaves. These inner scales elongate chiefly in the lower portion, which seems to correspond to the pedestal. They are, on the whole, more or less spathulate, but vary in form, and the apical portion seems to correspond to the lamina, because there is generally a trace of a joint or articulation. This apical portion is slightly more coriaceous and browner than the long and very membranous lower portion.

Some of the inner scales are more or less evidently trifid (fig. 130) or tridentate, the lateral lobes appearing to correspond to the shoulders seen below the pedestal of the normal and perfect leaf. The innermost scales (fig. 131) are suddenly widened at the apex, forming a hood or cap rolled round the apex of the bud and completely covering and protecting the young leaves.

CYCADACEÆ.

In Cycas (*Cycas revoluta*, Thunb.) one tier of leaves is produced every year, all developing simultaneously. The bud is covered with a mass of imbricate pro-leaves or scales. The latter are subulate, elongate, ending in a spine, dilated and triangular at the base, densely covered with a pale brown, woolly felt, erect or incurved in bud, ultimately spreading with age, but persisting for many years. Thus two sets of leaves are developed every year, each tier duly alternating.

In *Zamia* also (*Zamia Fischeri*, Miq.) the buds are protected by numerous scales.

HYDROCHARIDEÆ.

Limnobium bogotense, Karst.—The sheaths are large, membranous, colourless, intrapetiolar, connate in front of the petiole, but free at the other edges or readily separating when the contained bud or oldest leaf of it is about to expand, persistent, sheathing the short axis, and alternating with the leaves.

The terminal or crown-bud is covered by the sheath of the

youngest or last developed leaf, and successively by the sheaths of younger leaves, which are numerous. The leaves themselves are convolute in bud, being rolled up from one edge to the other.

Axillary buds arise in the axils of old sheaths and develop into stolons. The first node develops roots and two leafless, enveloping sheaths before a perfect leaf is formed. Their subsequent history is the same as that of the terminal bud or mother-bud.

HÆMODORACEÆ.

In *Sansevieria guineensis*, Willd., the leaves are radical, of two kinds, arising at the growing-points of an underground rhizome. Those on the rhizome beneath the soil are reduced to mere sheaths which soon perish. Above ground are five to six or more, also reduced to sheaths, but leathery, green, rolled round the bud and overlapping at the base, as well as closely imbricating over one another. The lower ones are mucronate, and the rest have a subulate point of greater or less length representing the laminæ.

The perfect leaf is usually solitary, and, like the rest, convolute in bud, but when developed, ligulate, entire, leathery, glabrous, convex on the back and shallowly grooved by the incurving of the sides.

The terminal bud is deeply sunk in the centre of the convolute, imbricating, cylindrical mass of leaves.

In *S. cylindrica*, Boj., the primary and modified leaves are about eight in number, dilated at the base, and closely imbricate, enclosing a solitary cylindrical leaf, which occupies the whole of the space between the scale-leaves.

TACCACEÆ.

Tacca artocarpifolia, Seem.—The crown or terminal bud is subterranean, and also covered by the sheath. The flower-scapes are leafless, but furnished with bracts beneath the flowers and with a leaf at the base reduced to the condition of a spathe, but which rises above the ground on the resumption of growth.

In *Tacca cristata*, Jack, the petiole is rather long, stout, deeply channelled with a sharply angular groove and strongly raised edges, glabrous, shining, deep purple-red, gradually and much dilated at the base, and incurved at the sides till the margins are nearly closed. The base of the lamina is decurrent upon the petiole, and the ridges of the latter are continued into the sheath at the base.

The terminal or axial bud is enclosed by the sheath of the youngest leaf, and the rest are imbricate.

The undivided lamina, the grooved petiole, and the large sheath of this species are all very different from those of *Tacca artocarpifolia.*

Roxburghiaceæ.

Stemona viridiflora, Benth. & Hook. f.—The terminal bud is subulate, elongate, or slenderly conical, covered in succession by each pair of leaves, which are incurved at the sides so as to cover the bud with very short petioles, or sessile in their earlier stages. The thickened and dilated base of the petiole is accommodated in the space left uncovered between the petioles of the next older pair of leaves while still in bud. The leaves remain erect and incurved at the sides for some time after they fold away from the bud.

Axillary buds are mostly flower-buds, and are sheltered by the dilated base of the petioles in their early stages.

The stems are annual, and produced from a subterranean, fusiform, tuberous rootstock or rhizome.

Liliaceæ.

Dianella aspera, Reg.—Sheaths laterally compressed, equitant, dilated and amplexicaul at the base, closely aggregate and imbricate; the edges are pale and membranous, while the midrib is developed into a narrow wing, finely serrulate and prolonged on to the base only of the lamina.

The terminal bud is deeply sunk amongst the equitant sheaths. Axillary buds arise in the axils of the primary leaves at the base of the shoots. These leaves are very short and conduplicate, but not differentiated into sheath and lamina. The shorter ones are triangular, the longer more subulate, and all those that are undifferentiated into sheath and lamina become brown and die at an early age.

The leaf is conduplicate in bud; the sheath is permanently so and equitant, while the lamina unfolds as in most other species with conduplicate leaves and belonging to different orders. This is different from *Iris Pseudacorus* and *Helmholtzia glaberrima*, in which the lamina seems to be a dilatation of the midrib on the under and upper surface respectively, so that the lamina is at right angles with the axis instead of being parallel with it.

PHILYDRACEÆ.

Helmholtzia glaberrima, Caruel.—Here, again, the axial or terminal bud is protected by the equitant bases of the leaves.

Axillary buds seldom develop, but they also would be protected by the same means as the terminal one.

JUNCACEÆ.

Prionium Palmita, E. Mey.—Leaves dilated at the base, imbricate and sheathing, persistent.

The stems are woody, erect, slow-growing, and closely invested for many years both by living and dead leaves, the tough fibrous tissue of which resists decay for a long time.

The sheaths are gradually dilated towards the base, but suddenly widened there, surrounding a considerable portion of the stem, whose edges are perfectly continuous with those of the lamina.

Terminal bud very large, continuous, consisting of many erect leaves which attain a length of 75 cm. to 1 m. before becoming exposed.

Axillary buds seldom developing, except when the terminal bud is injured or destroyed, accidentally or otherwise. Fresh or additional stems usually arise from the base of the plant, as suckers from the creeping rhizome.

PALMÆ.

Cocos nucifera, Linn.—The sheath is entire, and consists of several layers of brown fibres, some of which are longitudinal, while other series cross each other diagonally in an ascending direction, and form a layer like woven stuff of very coarse texture. The fibres are more or less mixed with membranous, more perishable material; they arise or are given off from the edge of the petiole. The sheath may be compared to others occurring amongst Monocotyledons, and differs only in the extraordinary development of the fibrous portion, while the membranous matter is more perishable.

The terminal bud is deeply sunk amongst the imbricating bases of the petioles and surrounded by the sheath, which is ultimately split by the swelling of the axis. The developing leaf is compactly folded, with the pinnæ imbricated in a rod-like mass, attaining a great length before it unfolds and pushes up from the centre of the crown of leaves.

Axillary buds seldom or never develop.

Pinanga Dicksonii, Blume.—The petiole is semiterete, deeply grooved above, with sharp edges, dilated towards the base, and then suddenly widening into a connate, cylindrical sheath surrounding the axis. The older ones enclose the base of the younger, but ultimately split by the thickening of the axis and the increase of the number of leaves.

The terminal bud is completely enclosed in the centre of the imbricating sheaths. The segments of the leaves in the bud state are densely imbricated and compacted into a smooth, rod-like body, terete towards the base, compressed and pointed upwards. The developing leaf pushes out of the mass of sheaths in this form and attains a length of 1·2–1·7 m. before it commences to unfold, and is so firm as to be safe from injury from all ordinary dangers, and even from the storms of wind or rain to which it might be subjected in a tropical country.

PANDANEÆ.

Freycinetia Banksii, Cum.—Here also the terminal bud is deeply sunk amongst, and protected by, the sheathing and more recently developed leaves. The stem is completely covered with the imbricating sheaths for some years.

Axillary buds are seldom developed, but arise sometimes upon the naked portion of the stem. They are protected by numerous imbricate leaves reduced to the condition of sheaths with only the rudiments of a lamina.

CYCLANTHACEÆ.

Carludovica palmata, Ruiz et Pav.—Leaves alternate, much crowded or cæspitose by the non-development of the internodes, petiolate, exstipulate, palmately 3–6-partite, with the segments multifid, multicostate, plicate, glabrous, persistent; petioles very long, comparatively slender, laterally compressed, rather deeply and narrowly grooved above, gradually dilated to a wide, flattened, and sheathing base.

The terminal bud is covered by the bases of the numerous dilated petioles, which are crowded together and imbricate.

Axillary buds seldom develop, but where they do occur they are amply protected in their early stages by the broad bases of the petioles in whose axils they occur.

The plant has very much the aspect of a fan-leaved Palm.

AROIDEÆ.

Pistia Stratiotes, Linn.—Here also the bud is protected by a sheath which is free and inserted upon the axis opposite to the petiole; sheath membranous, transparent, and covering that portion of the bud not sheltered by the petiole, persistent.

The axial bud is sheltered in the centre of the rosette by the surrounding leaves, and enclosed by the sheaths of both old and young, unexpanded ones. In their early stages the leaves are sessile, and more or less strongly involute at the margins.

The axillary buds develop into stolons with a slender, terete, pubescent axis, bearing a rosette of leaves at the apex of an elongated internode. Before the stolon elongates these buds are sheltered by the older leaves of the plant.

In *Chamæcladon lanceolatum*, Miq. (fig. 132), the leaves are crowded on a short axis, alternate, arranged on the $\frac{1}{3}$ plan, sheathing at the base, petiolate, lanceolate-elliptic, entire, cuspidate, incurvinerved, glabrous, evergreen. The sheaths are largely developed, half the length of the petiole, dilated at the base, clasping the axis and several of the younger leaves. They are adnate to the petiole but free for a short distance at the apex, and resembling stipules in that respect, submembranous towards the margin only.

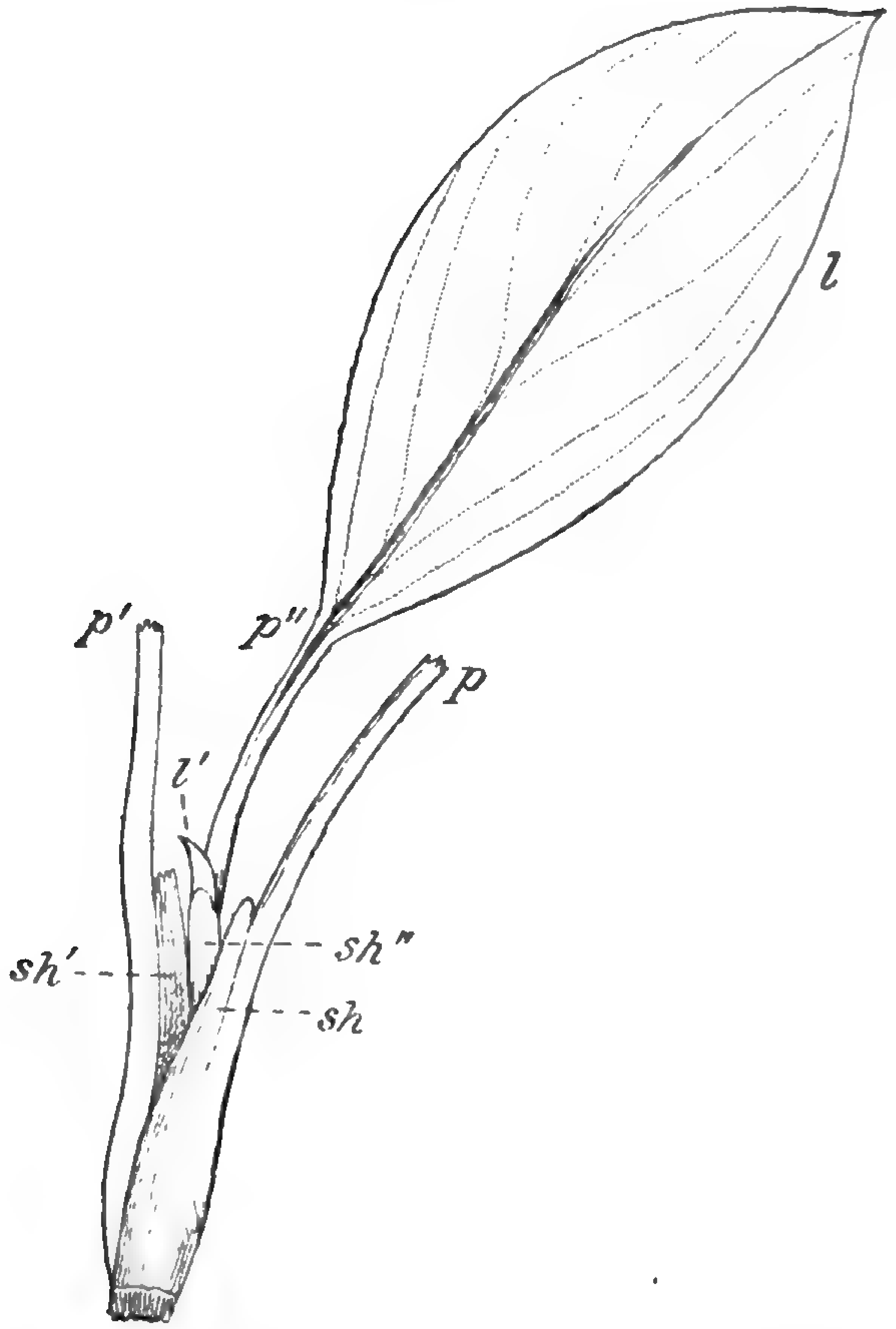
The terminal bud is completely invested by the sheath of the youngest expanded leaf, and ultimately emerges from the free apical portion of the sheath, which is the first part to open.

The axillary buds are protected by the investing sheaths of the older leaves, but only a few of them develop into shoots. This may be accounted for by the shortness of the stems and internodes, and the consequent lack of space to expose additional sets of leaves to the light.

Pothos (fig. 133).—The lamina is said to be absent in some species. The 'Genera Plantarum' describes the lower portion of the leaf as a winged petiole, but that of *P. Loureiri*, Hook. & Arn., seems to correspond with the sheath of many Orchideæ, and which is also articulate with the lamina.

The terminal bud is completely enclosed by the convolute sheath and lamina of several successive leaves, the lamina of the next younger leaf being the first to become protruded from the sheath of the most recently unfolded leaf. Every leaf is of considerable size and age before it becomes exposed.

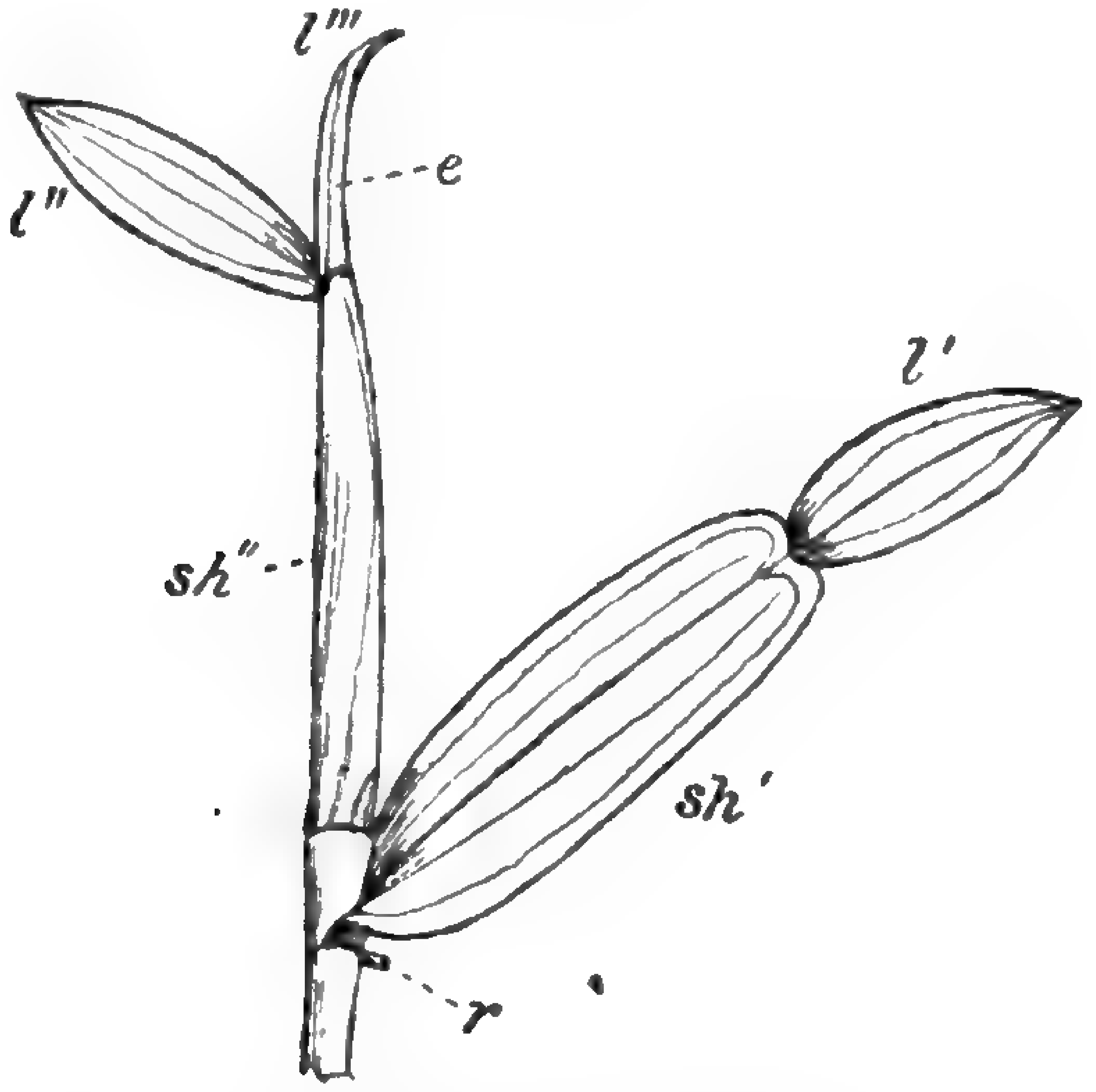
Fig. 132.



Chamæcladon lanceolatum, nat. size.

p, *p'*, *p''*, petioles of three leaves in their order of development; *l*, *l'*, laminæ of two leaves in their order of development; *sh*, *sh'*, *sh''*, sheaths of leaves in their order of development; *sh''* belonging to *p''*.

Fig. 133.



Pothos Loureiri, nat. size.

r, adventitious root; *sh'*, expanded sheath of leaf; *sh''*, unexpanded sheath of younger leaf; *l'*, *l''*, *l'''*, laminæ of three leaves in order of development; *e*, edge of convolute lamina, *l'''*.

The axillary buds are long, remain small, and are sheltered in the depression or fold at the base of the otherwise expanded sheaths.

The articulation at the point of union between the lamina and the sheath of the leaf of *Pothos Loureiri* gives it the appearance of a compound leaf, and forcibly recalls what exists in the species of *Citrus*, such as *C. Aurantium*, *C. Decumana*, &c., which have a winged petiole, auricled at the apex and articulated with the lamina. *Limonia* and *Murraya*, belonging to the same order, have compound leaves. The petioles of *Limonia acidissima* are likewise winged. In *Phyllarthron comorense* the leaves consist of 2–5 oblong-cuneate, flat joints, and appear to be dilatations or winged expansions of the common petiole of a compound leaf. Each joint or piece is generally retuse or truncate at the apex.

Thus, then, the outer scales which protect the winter-bud fall into at least seven categories.

They may be

1. Pedestals of last year's leaves, as, for instance, in *Pyrus Aria*.
2. Modified bases of leaves, as in the Maples and Horse-Chestnuts.
3. Leaf-blades, as in *Viburnum Lantana*.
4. Modified leaves, as in *Viburnum Opulus*, the Willows, &c.
5. Stipules, as in the Poplars, Oaks, Beech, &c.
6. Connate pairs of stipules belonging to the same leaf, as in the Elm and Spanish Chestnut.
7. Connate pairs of stipules belonging to different leaves, as in the Hop, *Gardenia* and other Rubiaceæ.

In conclusion, I have to express my thanks to Mr. Thiselton-Dyer and the staff of Kew, as also to Dr. Scott, for the facilities they have been good enough to give me, and to my excellent assistant Mr. Fraser for his valuable aid.

EXPLANATION OF THE PLATES.

Plate 12.

Fig. 1. *Tilia vulgaris*; young shoot.
2. The same, more advanced.
3. The same, with some of the leaves expanded.
4. *Carpinus Betulus*; young shoot.
5. The same, to show the folding of the leaves.

Plate 13.

Fig. 1. *Viburnum Opulus.*
2. *Acer platanoides*; young shoot.
3. The same, more advanced.
4. The same, still further advanced.
5. *Pyrus Aria*; sprig with three buds.

Plate 14.

Fig. 1. *Ulmus montana*; young shoot.
2. The same, more advanced.
3. The same, still more advanced.
4. The same, still further advanced.

Plate 15.

Figs. 1–6. Leaf-buds of *Fagus sylvatica* in different stages of development.

Fig. 7. Flower-bud of the same.

Note.—In fig. 1 the scales are represented too green; they should be a greyish-brown.

West, Newman lith.

DEVELOPMENT OF STIPULES.

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DEVELOPMENT OF STIPULES.

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DEVELOPMENT OF STIPULES

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DEVELOPMENT OF STIPULES

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As amended by the Council, 15th March, 1888.

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1. No more than Six volumes shall be lent to one person at the same time without the special leave of the Council or one of the Secretaries.

2. All books shall be returned before the expiration of Six weeks from the time of their being taken out, but if not required by any other Fellow, they may, *on application,* be kept for a further period of Six weeks.

3. All books lent shall be regularly entered by the Librarian in a book appropriated for that purpose.

4. No work forming part of Linnæus's own Library shall be lent out of the Library under any circumstances.

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The present number of the Journal is the fourth issued under the new regulations, which are as follow:—

Papers read from November and before the middle of January are published on **1st April.**

Papers read after the middle of January and before the end of April are published on **1st July.**

Papers read in May and June are published on **1st November.**

NOTICE.

Vol. XXVI. is still in course of issue, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–219. (Complete.)

Vol. XXXII., Nos. 220–227. (Complete.)

Vol. XXXIII., Nos. 228, 229, and 230 (the present Part).

Attention to this announcement is specially requested, to prevent application to the Librarian for unpublished Parts.

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All communications relating to the general business of the Society should be, as heretofore, addressed to the "Secretaries," but letters on library business only should be addressed to the "Librarian."

APRIL 1. Price 3s.

THE JOURNAL

OF

THE LINNEAN SOCIETY.

VOL. XXXIII. BOTANY. No. 231.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

DESCRIPTION OF THE PLATES.

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On the Attraction of Flowers for Insects. By the Rt. Hon. Sir JOHN LUBBOCK, Bart., F.R.S., M.P., F.L.S., D.C.L., LL.D.

[Read 4th November, 1897.]

I CONFESS I should have thought that the researches of Christian Sprengel, Darwin, H. Müller of Lippstadt, Delpino, and others, had made it clear that while honey is the real object which attracts insects to flowers, colour and scent guide them to the prize; and that thus, as I have elsewhere said, it is to Insects "we owe the beauty of our gardens, the sweetness of our fields. To them, flowers are indebted for their scent and colour; nay, for their very existence in its present form. Not only have the present shape and outlines, the brilliant colours, the sweet scent, and the honey of (the) flowers been gradually developed through the unconscious selection exercised by insects; but the very arrangement of the colours, the circular bands and radiating lines, the form, size, and position of the petals, the relative situations of the stamens and pistil, are all arranged with reference to the visits of insects, and in such a manner as to ensure the grand object which these visits are destined to effect."*

Prof. Plateau, however, in three interesting memoirs†, has recently called this view in question, and his eminence as an observer of insect life justifies, and even demands, a reply.

He summarizes his conclusions as follows:—

"(i.) Les Insectes visitent activement les inflorescences qui n'ont subi aucune mutilation, mais dont la forme et les couleurs sont masquées par des feuilles vertes.

"(ii.) Ni la forme ni les couleurs vives des capitules ne semblent avoir d'action attractive.

"(iii.) Les fleurons périphériques colorés des Dahlias simples, et, par conséquent, des capitules des autres Composées radiées, n'ont pas le rôle vexillaire ou de signal qui leur a été attribué.

"(iv.) La forme et la couleur ne paraissent pas avoir de rôle attractif; les Insectes sont évidemment guidés vers les capitules de Composées par un autre sens que la vue, sens qui est probablement l'odorat."‡

* 'Flowers and Insects,' p. 50.

† "Comment les Fleures attirent les Insectes": in Bull. Acad. Bruxelles, Sér. III. xxx. (1895) pp. 466–488; xxxii. (1896) pp. 505–534; xxxiii. (1897) pp. 17–41.

‡ *L. c.* xxx. p. 487.

Before, however, coming to Prof. Plateau's new observations, it is necessary to have a clear idea of how Bees act.

If a Hive-bee is brought to, or finds, a small quantity of honey, she laps up all she can, carries it off to the nest, and returns for more, often accompanied by one or more companions. It is, I believe, immaterial, or nearly so, to the Bee on what the honey rests, so long of course as it is not tainted. If during the Bee's absence the honey is moved, the Bee returns to the same place, and then hawks about, looking for it all round. Even if it is covered over, she will find it sooner or later.

I tried various experiments, placing the honey on slips of glass placed on coloured paper.

It must be remembered, as Aristotle was the first to mention, that the Hive-bee keeps to one kind of flower in each round of visits. Now, suppose a Bee to be visiting—say a daisy. In nature flowers are more or less scattered; they do not, at least not in all cases, grow in masses as in our gardens. It must be clear to everyone that when the Bee has finished the flowers on one plant, and has to find another of the same species, the coloured flowers would be a great help. Let anyone put a drop of honey on a leaf, and another on a piece of white, yellow, red, or blue paper on a grass-plot, and see whether the latter is not much the more easy to find.

I now pass to Prof. Plateau's experiments.

1.

The first were made with single Dahlias. He cut some squares of coloured paper (red, violet, white, and black), and in the centre of each he pierced a circular hole corresponding in size with the yellow heart of the flowers. He then pinned these papers on to some of the flowers.

He then says:—"On aurait pu supposer que les Insectes se seraient portés exclusivement sur les autres capitules intacts voisins en grand nombre et auraient négligé complètement les inflorescences masquées."

I should not myself have drawn any such conclusion. The paper disks must have been very conspicuous: the insects were already accustomed to come to the bed of flowers, and, once there, would readily find the groups of central florets. Moreover, Prof. Plateau does not give us the number of visits to other flowers, so that no comparison is possible.

2.

He then cut some disks without central holes, and pinned them over the flowers so as to hide, without touching, the tubular flowers. The visits of insects were about as numerous as before.

To this experiment, however, the same objections may be made as to the first.

I might also observe that to us Dahlias have no scent, and though it is possible that they may nevertheless emit an odour attractive to insects, there is no evidence of this. Surely it is somewhat illogical to assume that the Bees are guided by the sense of smell, when we have no evidence that, as a matter of fact, any scent is emitted.

3.

In his next series of experiments, Prof. Plateau used leaves instead of coloured paper. The results were similar, but the experiments are open to the same objections.

Yet he observes that "Après ces expériences, il semble, au moins pour les Insectes observés, que ni la forme ni la couleur des fleurs ne les attirent; que c'est surtout et peut-être exclusivement l'odorat qui les guide." Surely in any case, and even apart from the remarks already made, this is not a logical sequence. The theory which Prof. Plateau attacks is that insects are attracted to flowers by their smell and colour. It is part of the theory that the scent of flowers is important as attracting insects. Even if Prof. Plateau had proved, which I submit he has not, that in his experiments the insects were attracted by smell, and that they did not see the coloured corollas, this would not prove that they are not guided by the coloured corollas when they *can* see them.

4.

In his next series of experiments Prof. Plateau masked all the flowers, and yet insects came. "Dans ces conditions," he says, "l'observateur placé devant la rangée de Dahlias ne voit plus aucune fleur." No; but let him move round, as Bees would, and he would see the backs and sides of the flowers, which would be quite sufficient.

Moreover, it is evident that on previous days the Dahlias had been visited abundantly by insects. These would of course return, and though they might be a little disconcerted by Prof. Plateau's disks, the flowers would have to be much better hidden if they were to remain undiscovered.

5.

In the next series, Prof. Plateau repeated the well-known observations of Darwin on Lobelia, with results somewhat different from those of our great naturalist, but yet, I submit, pointing to the same conclusion.

Darwin's statement * was, "That the coloured corolla is the chief guide cannot be doubted. On a fine day, when Hive-bees were incessantly visiting the little blue flowers of *Lobelia erinus*, I cut off the petals of some, and only the lower striped petals of others, and these flowers were not once again sucked by the Bees, although some actually crawled over them. The removal of the two little upper petals alone made no difference in their visits."

Plateau experimented as follows † :—"Deux pots de Lobelia sensiblement identiques, portant l'un et l'autre de trente à quarante fleurs, sont placés en plein air, à une bonne exposition (sud) et a 50 centimètres l'un de l'autre.

"On les a posés chacun sur une planchette terminant un piquet, de manière qu'ils dépassent d'une vingtaine de centimètres les plantes basses avoisinantes."

The corollas were removed from the flowers in one of the pots, and the result was that 33 insects visited the intact flowers, and 25 those which were mutilated. Here, in the first place, the experiment was not continued long enough. In the second, they were only 50 centimetres apart, and insects which had visited the first pot would naturally proceed to the second.

The difference in numbers was marked ; and, indeed, just what I should have expected under the circumstances.

6.

His next series of experiments were on *Œnothera biennis.* He removed all the corollas ‡, and "l'Abeille qui visite la plante vole dans tous les sens, vers les fleurs fanées, vers les boutons, même sur les pétales tombés à terre qu'elle examine assez attentivement en se promenant dessus ; cependant *elle ne se pose pour butiner que sur les fleurs mutilées privées de corolle.*"

It will be noticed that the Bee visited the buds, the faded flowers, and even the *petals on the ground*, evidently attracted

* 'The Effects of Cross- and Self-Fertilization in the Vegetable Kingdom': London, 1876, p. 420.

† Bull. Acad. Bruxelles, Sér. III. xxx. (1895) p. 510.

‡ *L. c.* p. 516.

by the coloured corolla, and surely the simple and sufficient reason why it did not light on them was that they contained no honey.

7.

He treated in a similar way some flowers of an *Ipomœa purpurea*. Here, however, I should make the same objection as made to Series 4. In this case also he gives no comparison with unmutilated flowers.

8.

I pass over some similar observations on *Delphinium Ajacis*, *Centaurea Cyanus*, *Digitalis purpurea*, *Antirrhinum majus*, *Heracleum Fischeri*, &c., to which, I submit, the same criticisms apply.

9.

The next experiment was with the Cornflower (*Centaurea Cyanus*). Bonnier, in his 'Mémoire sur les Nectaires,' observes that in a field containing white as well as blue Cornflowers (*Centaurea Cyanus*), the Bees seemed (as is indeed probable) to visit them both nearly equally. Prof. Plateau says: "Mes observations, tout en confirmant celle de Bonnier, sont plus complètes." The Cornflowers observed by Plateau were of four colours—blue, purple, rose, and white. He records 16 visits by two Hive-bees, and 14 by four Megachiles, and observes that "l'indifférence pour la coloration est du reste à peu près complète." The number of visits seems to me quite insufficient to justify any conclusion, but so far as they go they tend to confirm my experiments recorded in this Journal, which showed a preference for blue, since out of 30 visits recorded by Prof. Plateau, 16 were to blue flowers, 6 to purple, 6 to white, and 2 to rose. Prof. Plateau adds, however, that "la préférence apparente pour les capitules bleus tient à cette particularité, indiquée plus haut, que ceux-ci étaient plus nombreux que les autres variétés." He does not, however, tell us what the respective numbers of the different coloured flowers were, and under all the circumstances no conclusion whatever can, I submit, be drawn from the observation.

10.

He proceeds to dwell on the existence of certain flowers which are inconspicuous, and yet, in consequence of their strong scent, much visited by insects. If anyone denied that scent serves to

attract insects, this fact would no doubt be a complete reply. It is none, however, to those who fully admit the importance of scent in attracting, or, I should rather say, guiding insects to flowers.

11.

Prof. Plateau then refers to the experiments of Perez, who placed drops of honey in certain flowers (Scarlet Pelargoniums) which contain no honey, and are therefore neglected by Bees; when, however, drops of honey were put in them, insects are ere long attracted by the scent of the honey. Perez, however, tells us that, after awhile, "La couleur écarlate s'était si bien associée dans leur souvenir à l'idée du miel, qu'elles se posaient à la fin sur des fleurs de cette couleur n'en ayant pas reçu, et ne les quittaient qu'après s'être assurées, par un examen scrupuleux et persistant, qu'elles n'avaient rien à y recueillir." Here, therefore, Perez clearly shows that the Bees were attracted by the red colour.

Prof. Plateau, indeed, states that his experiments did not in this respect confirm those of Perez. Yet he, himself, subsequently says, "Lorsque l'insecte avait ainsi absorbé le liquide d'un certain nombre de fleurs miellées, il lui arrivait de se diriger vers les Pelargoniums non munis de miel." This statement confirms that of Perez, and shows that the Bees, having found honey in some scarlet Pelargonium flowers, went and inspected others. In this case they were evidently guided by the colour, for, as already mentioned, the scent of scarlet Pelargoniums does not attract them. This seems a crucial case, fatal to Prof. Plateau's contention.

12.

Lastly, Prof. Plateau made some final observations on single Dahlias. Selecting a plant in the middle of a group, he carefully removed the central flowers and consequently the honey, leaving, however, the conspicuous ray-florets. Having done so, he says*:—"Durant trois quarts d'heure d'observation attentive, on ne voit aucun insecte se poser sur les inflorescences transformées." But why should they do so when the honey had been removed? He adds, however, that "Les Bourdons ou les Mégachiles qui quittent les capitules de Dahlias intacts se portent naturellement assez souvent vers les Dahlias mutilés mélangés aux précédents, mais ces insectes se bornent à décrire devant ces inflorescences quelques courbes prouvant incontest-

* Bull. Acad. Bruxelles, Sér. III. xxxiii. (1897) p. 39.

ablement un examen rapide, puis fondent tout droit sur un Dahlia intact." This behaviour is natural from our point of view, because they were attracted by the coloured ray-flowers; but seems quite inconsistent with Prof. Plateau's contention that scent is the only attraction, because the honey-bearing florets had been removed. So far from supporting his view, therefore, these last observations weaken, if they do not disprove it.

The experiments which the Society has already done me the honour of publishing, and which I subsequently brought together in my two books 'Ants, Bees, and Wasps,' and 'The Senses and Intelligence of Animals,' seem to me conclusively to have proved that Bees and other insects can distinguish, and are attracted by, the colours of flowers.

I have, however, made some more experiments, following to some extent the idea of Prof. Plateau, and endeavouring to get a crucial test between the respective attractions of scent and colour. I brought a Hive-bee up to my room, and, when she had got accustomed to come to some honey on a particular part of the table, I put out, a foot on one side of the place where the honey had been, the flower-head of an *Eryngium amethystinum* after removing the blue bracts, with a drop of honey on an ordinary glass microscopic slide; and, a foot on the other side of the place where the honey had been, a similar slip of glass with a drop of honey, and placed close to it the blue bracts. These, I need not say, are brilliantly blue, and measure about 4 inches across. The flower-head, on the contrary, though an inch in length, is not conspicuously coloured. Now, if insects were attracted by the scent of the honey alone, they would in such circumstances go to the drop of honey near the flower-head, or to the flower-head itself, and not to the bracts. While if they were attracted both by colour and scent, they would go sometimes to the one and sometimes to the other, —probably, as the bracts are so conspicuous, more often to the honey close to them. For shortness, I will indicate the flower-head and the drop of honey near it as F, the drop close to the bracts as B.

A few minutes after the original drop of honey was removed, the bee returned at 3.59, and, after buzzing about a little, settled on B After each visit I transposed the flower-head and bracts, leaving, however, the two drops of honey. This, of course, eliminated any possible difference as regards the honey. The Bee returned as follows:—

2	to	B	6	to	B
3	„	B	7	„	B
4	„	B	8	„	F
5	„	F	9	„	B

The following day I repeated the same experiment. The Bee returned as follows:—

10	to	B	19	to	B
11	„	B	20	„	F
12	„	B	21	„	B
13	„	B	22	„	F
14	„	F	23	„	B
15	„	F	24	„	F
16	„	B	25	„	B
17	„	F	26	„	F
18	„	B	27	„	B

Again, the next day:—

28	to	B	50	to	B
29	„	B	51	„	B
30	„	F	52	„	F
31	„	F	53	„	B
32	„	F	54	„	F
33	„	B	55	„	B
34	„	B	56	„	F
35	„	F	57	„	B
36	„	B	58	„	B
37	„	B	59	„	F
38	„	F	60	„	F
39	„	B	61	„	F
40	„	B	62	„	B
41	„	F	63	„	B
42	„	B	64	„	B
43	„	B	65	„	B
44	„	B	66	„	B
45	„	F	67	„	F
46	„	B	68	„	B
47	„	F	69	„	B
48	„	B	70	„	B
49	„	B	71	„	B

72	to	B	83	to	F
73	„	B	84	„	F
74	„	B	85	„	F
75	„	B	86	„	F
76	„	B	87	„	B
77	„	B	88	„	B
78	„	B	89	„	B
79	„	F	90	„	B
80	„	F	91	„	B
81	„	F	92	„	F
82	„	F	93	„	B

In these 93 visits, therefore, the Bee came 60 times to the honey near the bract, and 33 times to that near the flower-head itself.

I then applied the same test, placing, however, the drops of honey, with the flower-head and the bracts respectively, near the bed containing the growing plants and moving them about after each visit. Sixteen Bees came to the honey near the bracts, seven to that near the flower-head.

These observations go far, I think, to disprove Prof. Plateau's conclusion.

Such observations need to be made with much care, and it is not safe to assume that the senses of animals are exactly similar to ours. For instance, saccharine and sugar have to us the same sweet taste. I, myself, am quite unable to distinguish them. I, however, placed side by side two saucers containing water sweetened (1) by sugar and (2) by saccharine, and found that while Bees and Ants thoroughly enjoyed the first, they would not touch the second.

In conclusion, then, I submit that the observations made by Prof. Plateau do not at all weaken the view that the colours as well as the scent of flowers serve to attract Insects and guide them to the honey, in securing which they confer upon the plants the great advantage of cross-fertilization.

On some Desmids of the United States.

By W. West, F.L.S., and G. S. West, A.R.C.S.

[Read 2nd December, 1897.]

(Plates **16–18**.)

A very promising worker at North-American Desmidieæ, Mr. L. N. Johnson, of Ann Arbor University, Mich., whose early decease is much to be regretted, left some valuable notes and drawings. These came into the hands of Prof. W. G. Farlow, of Cambridge, Mass., by whom they were sent to Dr. Nordstedt, of Lund, Sweden, to examine, and with a request that anything coutained therein worthy of mention should be published. Dr. Nordstedt, who was much occupied, wrote and asked if we would undertake the matter, as we had lately been working at American Desmids. We assented to his request as Mr. Johnson had been a much-valued correspondent of ours; and the following paper is the result of a careful consideration of his notes and drawings, the examination of some material received from him about a year ago, together with many observations on collections of Desmids from the United States in our possession.

Johnson's notes and drawings, made during his examination of a large number of gatherings of Desmids from all parts of the United States, add much to our knowledge of their distribution. In the course of his work he published three papers *, in which he recorded many important observations on the less-known American Desmids, and described and figured several new species; and we now find other well-marked new species among his recent drawings. This work clearly testifies that he was *facile princeps* among the American workers at this class of plants. He also left an herbarium of microscopical preparations, to which reference has been given under the majority of the species in this paper (*e. g.* H. J. no. 535); and as he continually refers to it in his notes, we think it must be a valuable one, though in whose possession it is we do not know.

All the figures are from drawings by Johnson, except the following:—Pl. **16**. figs. 10–13; Pl. **17**. fig. 16; Pl. **18**. figs. 1, 4, 8, 10, and 15; figs. xylogr. 1, 3, 5 *a–c*, 6 *c–f*, and 7.

* "On some species of *Micrasterias*," Botan. Gazette, vol. xix. (1894). "Some new and rare Desmids of the United States, I.," Bull. Torr. Bot. Club, vol. xxi. No. 7 (1894); II., vol. xxii. No. 7 (1895).

I. GONATOZYGON, *De Bary.*

1. G. ACULEATUM, *Hastings, in Amer. Month. Micr. Journ.* (1892) p. 29; *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 230, pl. 12. ff. 1, 2.

Hab. Laconia, N.H., frequent in pond.

2. G. PILOSUM, *Wolle, Desm. U. S.* p. 22, pl. 1. f. 2.

Lat. 14 μ.

Hab. Lamp Mortar Rock, Fairfield, Conn., scarce (H. J. no. 192).

3. G. RALFSII, *De Bary, Conj.* pp. 76–7, t. iv. ff. 23–25.

Lat. 10 μ.

Hab. New Baltimore, Mich. (H. J. no. 273). Holderness, N.H., scarce. Wake Forest, N.C., common (H. J. no. 534). Cold Spring Harbour, N.Y. (H. J. no. 144).

4. G. BRÉBISSONII, *De Bary, l. c.* p. 77, t. iv. ff. 26, 27.

Lat. 6–8 μ; long. cell. 136–160 μ.

Hab. De Land, Florida, very rare. Seattle, Wash. Laconia, N.H.

II. SPIROTÆNIA, *Bréb.*

5. S. CONDENSATA, *Bréb. in Ralfs, Brit. Desm.* p. 179, t. 34. f. 1.

Lat. 18–24 μ.

Hab. Fairfield, Conn., not rare with *Mougeotia* sp. in Mill River (H. J. no. 173). Cold Spring Harbour, N.Y., frequent in lower pond. Wake Forest, N.C., very scarce. Cœur d'Alene, Idaho, scarce in pool by crest (H. J. no. 621).

Forma MINOR.

Lat. 12–15 μ.

Hab. De Land, Florida, scarce.

III. MESOTÆNIUM, *Näg.*

6. M. MACROCOCCUM, *Roy et Biss. in Ann. Scot. Nat. Hist.* Oct. 1894.—Palmoglœa macrococca, *Kütz. Phycol. Germ.* p. 153 (1845); *Tab. Phyc.* i. t. 24. f. 2.—Mesotænium Braunii, *De Bary. Conj.* p. 74, t. 7. A. ff. 1–8 (1858).

Lat. 12 μ.

Hab. Near Whitmore Lake, Northfield, Mich. (H. J. no. 146).

7. Mesotænium Endlicherianum, *Näg. Gatt. Einz. Alg.* p. 109, t. vi. B.

Lat. 10–12 μ; 2–4 times longer than the diameter.

Hab. Palo Alto, Calif., abundant in small pool (H. J. no. 538).

IV. CYLINDROCYSTIS, *Menegh.*

8. C. americana, n. sp. (Pl. **18**. figs. 5, 6.)

C. magna, circiter $2\frac{1}{3}$-plo longior quam lata; cellulis cylindricis, in medio distincte constrictis, apicibus rotundatis (semicircularibus); membranâ achroâ; pyrenoidibus magnis singulis in centro semicellularum, chromatophoris conspicue radiantibus.

Long. 52 μ; lat. 22–24 μ.

Hab. Ithaca, N.Y. (H. J. no. 499).

This species appears to be sufficiently distinct from *C. diplospora*, Lund., the cylindrical cells and semicircular apices being quite characteristic. It resembles *Penium rufescens*, Cleve, in form, but it is a little smaller and has a colourless membrane; moreover, the chlorophyll is arranged as in *Cylindrocystis*.

9. C. angulata, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. *Bot.* v. p. 237, pl. 13. ff. 25, 26.—C. tumida, *Wolle, Alg. U. S.* p. 23, pl. 56. ff. 7, 8, *non F. Gay.*

A rather smaller and proportionately narrower form: long. 62 μ; lat. 21 μ; lat. isthm. 20 μ.

Hab. De Land, Florida (H. J. no. 590).

V. PENIUM, *Bréb.*

10. P. Clevei, *Lund. in Act. R. Soc. Scient. Ups.* Ser. III. viii. no. 2, p. 86, t. v. f. 11.

Long. 75–90 μ; lat. 30–33 μ.

Hab. Seattle, Wash. (H. J. no. 637).

"The smallest specimens are about one fourth smaller than Lundell's original measurements, but they resemble his figures exactly."

11. P. annulare, *West, in Journ. Bot.* xxix. Dec. 1891, p. 354, t. 315. ff. 5, 6.

Hab. Chester, S.C., common (H. J. no. 628).

"A peculiar form with the constrictions barely visible; lat. 25 μ. Must be a form of this species."

This plant is now known from Maine, Pennsylvania, Louisiana, and South Carolina.

12. PENIUM DIGITUS, *Bréb. in Ralfs, Brit. Desm.* p. 150, t. 25. f. 3. Closterium Digitus, *Ehrenb.*; C. lamellosum, *Bréb.*; Penium lamellosum, *Kütz.*; P. navigium, *W. B. Turn. in K. Sv. Vet.-Akad. Handl.* xxv. no. 5, p. 17, t. i. f. 9.

Johnson found this species abundant from many States. He remarks, "I fear I have not learned to distinguish *P. Digitus* from *P. lamellosum.*" *Cfr.* West & G. S. West in Journ. Bot. xxxiii. Mar. 1895, p. 66.

13. P. MARGARITACEUM, *Bréb. in Rafls, Brit. Desm.* p. 149, t. 25. f. 1 *a–c*.

Noticed from many States; lat. 22–32 μ. The specimens from Plymouth, N.H. (H. J. no. 353), are worthy of mention as they did not show the linear arrangement of the markings.

14. P. SPIROSTRIOLATUM, *Barker, in Quart. Jour. Micr. Soc.* N. S. ix. p. 194.

Long. 148–220 μ; lat. 16–19 μ.

Hab. De Land, Florida, not rare; also Tallahassee, Florida.

15. P. MINUTUM, *Cleve, in Öfv. K. Vet.-Akad. Förh.*, Arg. xx. 1863, no. 10, p. 493.—Docidium minutum, *Ralfs, Brit. Desm.* p. 158, t. 26. f. 5.

Var. CRASSUM, *West, in Journ. Linn. Soc.* (*Bot.*) xxix. p. 130, t. 20. f. 1.

The specimens were all rather more attenuate than any we have previously seen, and had a punctate cell-membrane. Long. 46–70 μ; lat. 12–19 μ.

Hab. Florida (H. J. no. 545).

VI. ROYA, *West & G. S. West.*

16. R. OBTUSA, *West & G. S. West, in Journ. Roy. Micr. Soc.* 1896, p. 152.—Closterium obtusum, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg*, iv. p. 154, t. 2. f. 46.

Lat. 7 μ.

Hab. Glencoe, Ill., 1890. Single specimen found (H. J. no. 85).

VII. CLOSTERIUM, *Nitzsch.*

17. C. LUNULA, *Nitzsch*; *Ralfs, Brit. Desm.* p. 163, t. 27. f. 1.

Hab. Near Tallahassee, Florida, scarce. "In some specimens a wide colourless sheath covered with dirt &c. was seen."

Wake Forest, N.C. "Some specimens showed a wide gelatinous covering around the cells."

18. Closterium Braunii, *Reinsch, Algenfl. Franken in Abh. Naturhist. Ges. zu Nürnberg*, iii. (1866) p. 196, t. 12. f. 5; *Joshua in Journ. Bot.* xxiii. (1885) p. 35, t. 254. f. 9.—C. areolatum, *H. C. Wood*, 1874; C. maculatum, *Hastings*, 1892.

Lat. circ. 50 μ.

Hab. Clay Co., Kansas, abundant (1895) (H. J. no. 636).

19. C. decorum, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg*, iv. p. 151, t. 2. f. 39.

Lat. circ. 32–40 μ.

Hab. Bridgeport, Conn., occasional (H. J. no. 331). New Baltimore, Mich., frequent (H. J. no. 330).

20. C. Delpontii, *Wolle, in Bull. Torr. Bot. Club*, xii. (1885) p. 2.—C. Ralfsii, *Bréb.*, var. Delpontii, *Klebs*, 1879; C. crassum, *Delp. (non Rabenh.)*.

Lat. 25–31 μ.

Hab. Staten Island, N.Y., very abundant (H. J. nos. 401 & 419). Bridgeport, Conn. Near Tallahassee, Florida. Easton, Conn., abundant in brook. Seattle, Wash., frequent.

21. C. prælongum, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg*, iv. p. 152, t. 2. f. 41.

Long. 710 μ; lat. 19 μ.

Hab. Seattle, Wash., scarce.

22. C. lineatum, *Ehrenb.*; *Ralfs, Brit. Desm.* p. 173, t. 30. f. 1.

Var. costatum, *Wolle, Alg. U. S.* p. 25, t. 61. f. 3.

Long. 820 μ; lat. 30–32 μ.

Hab. Wake Forest, N.C., occasional (H. J. no. 521). "Seems to be distinctly this form, but one specimen recently divided shows imperfectly more numerous striæ on the new half." Bridgeport, Conn. (1893 and 1895).

23. C. macilentum, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg*, iv. p. 153, t. 2. f. 36.

Long. 560 μ; lat. 16–20 μ.

Hab. New Baltimore, Mich. (H. J. nos. 286 & 303). Burlington, Kans., in ponds with *Azolla*.

24. CLOSTERIUM RALFSII, *Bréb. in Jenner, Fl. Tunbr. Wells*, p. x; *Ralfs, Brit. Desm.* p. 174, t. 30. f. 2.

Var. HYBRIDUM, *Rabenh. Fl. Europ. Alg.* iii. p. 135.

Long. 408 μ; lat. 32 μ.

Hab. Bridgeport, Conn.

25. C. STRIOLATUM, *Ehrenb.*; *Ralfs, Brit. Desm.* p. 170, t. 2 *g* et *f*.

Hab. Portland, Oregon: "a short form very like *C. didymotocum* in shape and size, but coarsely striate. Very abundant" (H. J. no. 415). Meredith, N.H., and Plymouth, N.H.: "forms like *C. didymotocum* except that ends were more rounded; coarsely striate; several cross-lines; upper margin nearly straight; diam. 40 μ" (H. J. no. 382). This may be var. *orthonotum*, Roy. Near Tallahassee, Florida: "a long form nearly straight on ventral margin and with truncate ends"; diam. 50 μ (H. J. no. 478).

26. C. DIRECTUM, *Arch. in Proc. Dubl. Nat. Hist. Soc.* (1862) p. 80, t. 2. ff. 23, 24.

Long. 170 μ; lat. 11 μ.

Hab. New Connecticut (H. J. no. 536).

27. C. JOHNSONII, n. sp. (Pl. **16**. figs. 1, 2.)

Cl. mediocre, cellulis diametro circiter 17-plo longioribus, subrectis et leviter sigmoideis, lateribus parallelis sed apices versus gradatim attenuatis, apicibus subtruncatis; membrana glabra.

Long. 357 μ; lat. 21 μ; lat. apic. 12 μ.

Hab. Plymouth, N.H. (H. J. no. 655).

This species seems to be sufficiently characteristic.

28. C. TOXON, *West, in Journ. Linn. Soc.* (*Bot.*) xxix. p. 121, pl. 19. f. 14.

Forma ELONGATA. (Pl. **16**. figs. 3, 4.)

Long. 350 μ; lat. 6–9 μ.

Hab. Florida (H. J. nos. 485 & 564).

29. C. TUMIDUM, *Johns. in Bull. Torr. Bot. Club*, xxii. (1895) p. 291, pl. 239. f. 4.—C. Cornu β, *Ralfs.*

Long. 130 μ; lat. 14–18 μ.

Hab. Horse Plains, Mont., frequent (H. J. no. 626). Holderness, N.H., frequent.

30. C. DIANÆ, *Ehrenb.*; *Ralfs, Brit. Desm.* p. 168, t. 28. f. 5.

Lat. 20–25 μ.

Hab. Whitmore Lake, Mich. (H. J. no. 435). Near Tallahassee, Florida (H. J. no. 477). "A very long form describing a semicircle, and with very little inflation in the middle. Very like a puzzling form found at Edgemoor, Ind., some years ago."

31. Closterium acutum, *Bréb. in Ralfs, Brit. Desm.* p. 177, t. 30. f. 5.

Lat. 12 μ.

Hab. Weston, Mass.; forming a green gelatinous mass on stones in stream (H. J. no. 4).

VIII. DOCIDIUM, *Breb.*

32. D. dilatatum, *Nordst. in Rabenh. Alg.* no. 2250; *Lund. in Act. R. Soc. Sc. Ups.* Ser. III. viii. no. 2, p. 88, t. 5. f. 12.—Pleurotænium dilatatum, *Cleve.*

Lat. 12 μ.

Hab. De Land, Florida, frequent (H. J. no. 578).

IX. PLEUROTÆNIUM, *Näg.*

33. P. nodosum, *Lund. in Act. R. Soc. Sc. Ups.* Ser. III. viii. no. 2, p. 90.—Docidium nodosum, *Bail. in Ralfs, Brit. Desm.* p. 218, t. 35. f. 8.

Long. circ. 400 μ; lat. ad bas. semicell. 55 μ; lat. apic. 30 μ.

Hab. Near Tallahassee, Florida, very scarce (H. J. no. 480). Laconia, N.H., not common (H. J. no. 668).

34. P. constrictum, *H. C. Wood, in Smithson. Contrib. Knowl.* xix. (1874) p. 121; *Lagerh. in Öfvers. Sv. Vet.-Akad. Förh.* (1886) no. 7, p. 251.—Docidium constrictum, *Bail. in Ralfs, Brit. Desm.* p. 218, t. 35. f. 7 (1848).

Lat. ad bas. semicell. 49 μ.

Hab. Laconia, N.H., scarce (H. J. no. 648).

35. P. Sceptrum, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*), v. p. 235, pl. 13. f. 6.—Docidium Sceptrum, *Kütz.*; D. tridentulum, *Wolle.*

Lat. 8–10 μ.

Hab. De Land, Florida, frequent (H. J. no. 614).

36. P. trochiscum, *West & G. S. West, l. c.* p. 235, pl. 13. ff. 4, 5.

Hab. De Land, Florida, very common.

The specimens agreed exactly with those originally described, and from the present state of our knowledge of this type of *Pleurotænium*, it is impossible to say whether this species, *Docidium verrucosum*, Bail., and *Pleurotænium tessellatum*, Lagerh., are identical or not. The figures and descriptions of *Docidium verrucosum* and *Pleurotænium tessellatum* are not sufficiently accurate to admit of a detailed comparison, but they agree in having the rectangular markings more numerous and regularly arranged, a character which, if correct (and this is very doubtful), readily distinguishes them from *P. trochiscum*. Only an examination of the original examples of *Docidium verrucosum* and *Pleurotænium tessellatum* can definitely determine the point.

X. TRIPLOCEROS, *Bailey*.

37. T. VERTICILLATUM, *Bail.* 1851.—Docidium verticillatum, *Bail. in Ralfs, Brit. Desm.* p. 218, t. 35. f. 9 (1848).

Lat. 45–47 μ.

Hab. Laconia, N.H., common (H. J. no. 649).

"All the specimens seen were characterized by having but two bidentate projections at each end."

38. T. GRACILE, *Bail.* 1851; *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 64, t. vii. f. 12.—Docidium gracile, *Wittr. in Nov. Act. Soc. Upsal.* Ser. III. vii. p. 21, t. 1. f. 10.

Lat. 20–26 μ.

Hab. De Land, Florida, occasional (H. J. no. 576). Laconia, N.H., occasional.

"All the specimens seen had *two* bidentate processes at each end. This is of interest in connection with the fact that all the specimens of *T. verticillatum* (which were abundant) showed the same peculiarity. Are these two species really distinct?"

XI. EUASTRUM, *Ehrenb.*

39. E. HUMEROSUM, *Ralfs, Brit. Desm.* p. 82, t. 13. f. 2.

Long. 104 μ; lat. 76 μ.

Hab. De Land, Florida, frequent (H. J. no. 595).

"More like Ralfs' figures than Wolle's."

Var. MAMMOSUM, *Schmidle, in Ber. der Naturfor. Ges. zu Freiburg*, vii. Heft 1, p. 106, t. 6. ff. 9, 10.

Long. 100 μ; lat. 60 μ.

Hab. De Land, Florida (H. J. no. 552).

40. Euastrum sinuosum, *Lenorm.* (1845); *Ralfs, Brit. Desm,* p. 85, t. 13. f. 5 *a*, *b*, *c* (1848).

Long. 56–60 μ; lat. 36–40 μ; lat. isthm. 10 μ; crass. 22 μ.

Hab. De Land, Florida, abundant (H. J. no. 600).

41. E. ansatum, *Ehrenb.* (1832); *Ralfs, l. c.* p. 85, t. 14. f. 2.

Var. turgidum, *Börgesen, in Vidensk. Medd. f. d. naturh. Foren. Kjöbenhavn* (1890), p. 938, t. 3. f. 15.

Hab. Wake Forest, N.C., abundant (H. J. no. 535).

"In some specimens the sides of the semicells are almost straight."

42. E. subhexalobum, n. sp. (Pl. **16**. fig. 7.)

E. parvum, circiter 1½-plo longius quam latum, profunde constrictum, sinu angusto-lineari; semicellulæ subtrilobæ, lobis lateralibus oblique truncatis, marginibus truncatis ad sinum convergentibus, lateribus multo concavis, lobo polari lato subrectangulari, angulis superioribus leviter rotundatis, apice convexo cum incisurâ profunde lineari in medio; a latere visæ subovatæ, apice rotundato-truncato, lateribus cum tumore singulo ad partem inferiorem; a vertice visæ ellipticæ, tumoribus binis ad medium utrobique.

Long. 40 μ; lat. 26 μ; lat. isthm. 6 μ; crass. 15 μ.

Hab. De Land, Florida (H. J. no. 586).

This species is closely allied to *E. quadrioculatum*, West & G. S. West, but as it possesses distinct characters we think it should be considered as another species. It is distinguished from the above-mentioned Asiatic species by its proportionately broader cells, its different lateral margins and basal angles, as well as in the apex and the poles of the vertical view.

43. E. pyramidatum, *West, in Journ. Linn. Soc.* xxix. (*Bot.*) p. 139, pl. 20. f. 13. (Pl. **16**. fig. 14.)

Long 28 μ; lat. 20 μ; lat. isthm. 6 μ.

Hab. Florida (H. J. no. 427 *a*).

The figures of this species previously given (*cfr. supra*) are very bad and do not adequately represent the species; we therefore give a more accurate figure of an American specimen.

43 *a*. E. intermedium, *Cleve, in Öfvers. Sv. Vet.-Akad. Förh.* (1864), no. 10, p. 484, t. 4. f. 1; *Lund. in N. Act. R. Soc. Sc. Ups.* Ser. III. vii. no. 2, p. 21, t. 2. f. 4.

The typical American form of this species appears to have

more produced lateral and polar lobes than the European plant; the specimens seen by Johnson show this and so do those contained in material received from him. (*Cfr.* also West & G. S. West in Trans. Linn. Soc. Ser. II. (Bot.) v. p. 242, pl. 14. ff. 18, 19.)

Long. 68 μ; lat. 42 μ; lat. isthm. 8 μ; crass. 22 μ.

Hab. De Land, Florida (H. J. no. 587).

Var. VALIDUM, n. var. (Pl. **16**. fig. 8.)

Var. robustum, lobis lateralibus et polaribus latioribus, angulo loborum lateralium sursum curvato.

Long. 70 μ; lat. 40 μ; lat. isthm. 8 μ; crass. 24 μ.

Hab. De Land, Florida (H. J. no. 584).

Var. PURUM, *nob.* (E. purum, *Wolle, Freshw. Alg. U. S.* p. 37, pl. 58. ff. 9–11.)

Var. angulis loborum lateralium polariumque late rotundatis, sinu minus aperto.

Hab. Florida and New Jersey.

44. EUASTRUM JOHNSONII, n. sp. (Pl. **16**. fig. 9.)

E. submediocre, $1\frac{1}{2}$-plo longius quam latum, profunde constrictum, sinu angusto lineari; semicellulæ subtriangulares, angulis basalibus late rotundatis, lateribus inferioribus binodulosis, lateribus superioribus concavis, apicibus late convexo-truncatis, annulo granulorum prope et circa apicem, tumoribus granulatis tribus in centro, eo mediano et inferiori cum annulo granulorum 5, iis superioribus et latera versus granulis 4 instructis, cum granulis circ. 4 intra angulos basales; a latere visæ ovatæ; a vertice visæ ellipticæ, tumoribus prominentibus utrobique, et in centro (circa apicem semicellulæ) cum annulo granulorum 16.

Long. 60 μ; lat. 40 μ; lat. apic. 17 μ; lat. isthm. 11 μ; crass. 26 μ.

Hab. New Connecticut (H. J. no. 523).

45. E. ATTENUATUM, *Wolle, Desm. U. S.* p. 103, pl. 26. f. 17; *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 243, pl. 14. ff. 20, 21.—E. Hastingsii, *Wolle, Desm. U. S.*, new edit. p. 113, pl. 42. ff. 16, 17.

Long. 64 μ; lat. 35 μ; lat. apic. 15 μ; lat. isthm. 11 μ; crass. 23 μ.

Hab. Seattle, Wash. (H. J. no. 638).

46. EUASTRUM GEMMATUM, *Ralfs* (1844); *Brit. Desm.* p. 87, t. 14. f. 4.

Long. 48–55 μ; lat. 39–52 μ; lat. isthm. 14 μ; crass. 26 μ.

Hab. Bridgeport, Conn. (H. J. nos. 178 & 226). Meredith (H. J. no. 369), Plymouth and Laconia, N.H. Seattle, Wash.

47. E. DOLIFORME, n. sp. (Pl. **16**. fig. 12.)

E. parvum, $1\frac{1}{2}$-plo longius quam latum, profunde constrictum, sinu angusto-lineari extremo subampliato; semicellulæ truncato-pyramidatæ, angulis basalibus rectangularibus, lateribus bi-undulatis, undulatione basali emarginato, angulis apicalibus mucronatis, apicibus latis truncatis et levissime convexis in medio leviter emarginatis, supra et juxta isthmum tumore prominenti; a vertice visæ subanguste ellipticæ, tumore mediana utrobique; membrana punctata.

Long. 41 μ; lat. 27 μ; lat. apic. 20 μ; lat. isthm. 10 μ; crass. 17 μ.

Hab. De Land, Florida.

48. E. BINALE, *Ehrenb.* (1840); *Ralfs, l. c.* p. 90, t. 14. f. 8 (1848).—Heterocarpella binalis, *Turp.* (1820).

Hab. Duval Co., Florida, abundant with zygosp. (H. J. nos. 298 & 307).

"Zygospore spiny, with the spines forked at tip."

49. E. SIBIRICUM, *Boldt, in Öfvers. K. Vet.-Akad. Förh.* 1885, no. 2, p. 99, t. 5. f. 2; *Johns. in Bull. Torr. Bot. Club* (1895), xxii. p. 292, t. 239. f. 13.

Hab. De Land, Florida, scarce.

50. E. CIASTONII, *Racib. in Rozpr. Akad. Krak.* Ser. II. ii. (1892), p. 384, t. 2. f. 28; *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 244, pl 14. f. 31.

Hab. De Land, Florida.

51. E. ABRUPTUM, *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* 1869, nos. 14–15, p. 217, t. 2. f. 3.

Forma MINOR. (Pl. **16**. fig. 10.)

Long. 28 μ; lat. 21 μ; lat. apic. 13·5 μ; lat. isthm. 4·5 μ.

Hab. Minneapolis, Minnesota.

52. E. OCULATUM, *Börgesen, in Vidensk. Medd. Foren. Kjöbenh.* 1890 (1891), p. 941, t. 3. f. 24.

Forma semicellulis in medio apicis emarginatis (non profunde incisis), angulis basalibus rotundatioribus. (Pl. **16**. fig. 13.)

Long. 48 μ; lat. 30 μ; lat. apic. 17 μ; lat. isthm. 8 μ; crass. 19 μ.
Hab. De Land, Florida.

53. Euastrum evolutum, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 243, pl. 14. f. 22 (1896).—E. abruptum, *Nordst.*, var. evolutum, *Nordst. in Öfvers. Sv. Vet.-Akad. Förh.* (1877), no. 3, p. 21, t. 2. f. 7.—E. Nordstedtianum, *Wolle, Desm. U. S.* pp. 105–6, pl. 26. ff. 7, 9–12 (1884).—E. coronatum, *W. B. Turn. in Journ. Roy. Micr. Soc.* Ser. II. v. pp. 935–6, pl. 15. f. 9 (1885).

E. mediocre, circiter $1\frac{1}{2}$-plo longius quam latum, profunde constrictum, sinu lineari extremo subampliato; semicellulæ suboblongæ vel pyramidato-trapeziformes, 5-lobæ, incisuris lateralibus similibus apertis et rotundatis; lobis lateralibus et basalibus similibus, subrotundatis vel subtruncatis, inferioribus paullo majoribus, spinis brevibus validis 3 (sæpe 2 vel 4) ad marginem et spina singula (vel rarius spinis binis) intra marginem; lobo polari maximo, late oblongo et truncato, lateribus rotundatis cum spinis brevibus plerumque 2, angulis apicalibus cum spina singula valida divergenti (longitudinis variabilis) instructis, incisura mediana profunda et subaperta, intra marginem apicalem cum verruca rotundata, emarginata vel bidenticulata juxta incisuram apicalem utrobique: in centro semicellularum verruca magna subtrilobata, juxta sed supra verrucam cum scrobiculis magnis binis, intra angules inferiores et juxta sinum cum granulo magno singulo (vel verruca emarginata); a latere visæ angulari-ovatæ, basin versus cum verruca magna emarginata utrobique, angulis superioribus emarginatis, in medio apicis cum dente instructa; a vertice visæ ellipticæ, polis denticulatis, in medio utrobique cum verruca magna emarginata.

Long. 60–71 μ; lat. 37–47 μ; lat. isthm. 10·5–15 μ; lat. lob. polar. 30–35 μ; crass. 27·5–31 μ. (Fig. xylogr. 1 *a* et *b*.)

Hab. Minneapolis, Minnesota; Scarbro', Maine; &c.

This species, originally described from Brazil as a variety of *E. abruptum* and since found in S. Africa (*cfr.* Nordstedt, in Act. Univers. Lund. vol. xvi. (1880), p. 10), is a frequent North American species of *Euastrum*; and after examining hundreds of specimens from many parts of the United States, we have become well acquainted with its various forms. For an account of its distinctive peculiarities *vide* West & G. S. West, l. c.; it is a very distinct plant from *E. abruptum*, a figure of a small form of which we give for comparison (Pl. 16. fig. 10).

The variable species so very badly described and figured by Wolle as *E. Nordstedtianum* is without question *E. evolutum*, as specimens of an *Euastrum* received from him from Minneapolis, Minnesota (one of the most abundant habitats of *E. Nordstedtianum*, cfr. Desm. U. S. p. 106), are identical in all respects with *E. evolutum*. The figures of front, vertical, and lateral views given by Wolle are too crude and inaccurate to be of any value. *E. coronatum*, W. B. Turner *, of which we possess the original (and numerous) examples, is also this species in its most typical form; Turner's figure and description are incorrect. It is also rather remarkable that the specimens described as *E. coronatum* by Turner came originally from the late Rev. F. Wolle, and are from the same locality as those described by the latter as *E. Nordstedtianum*.

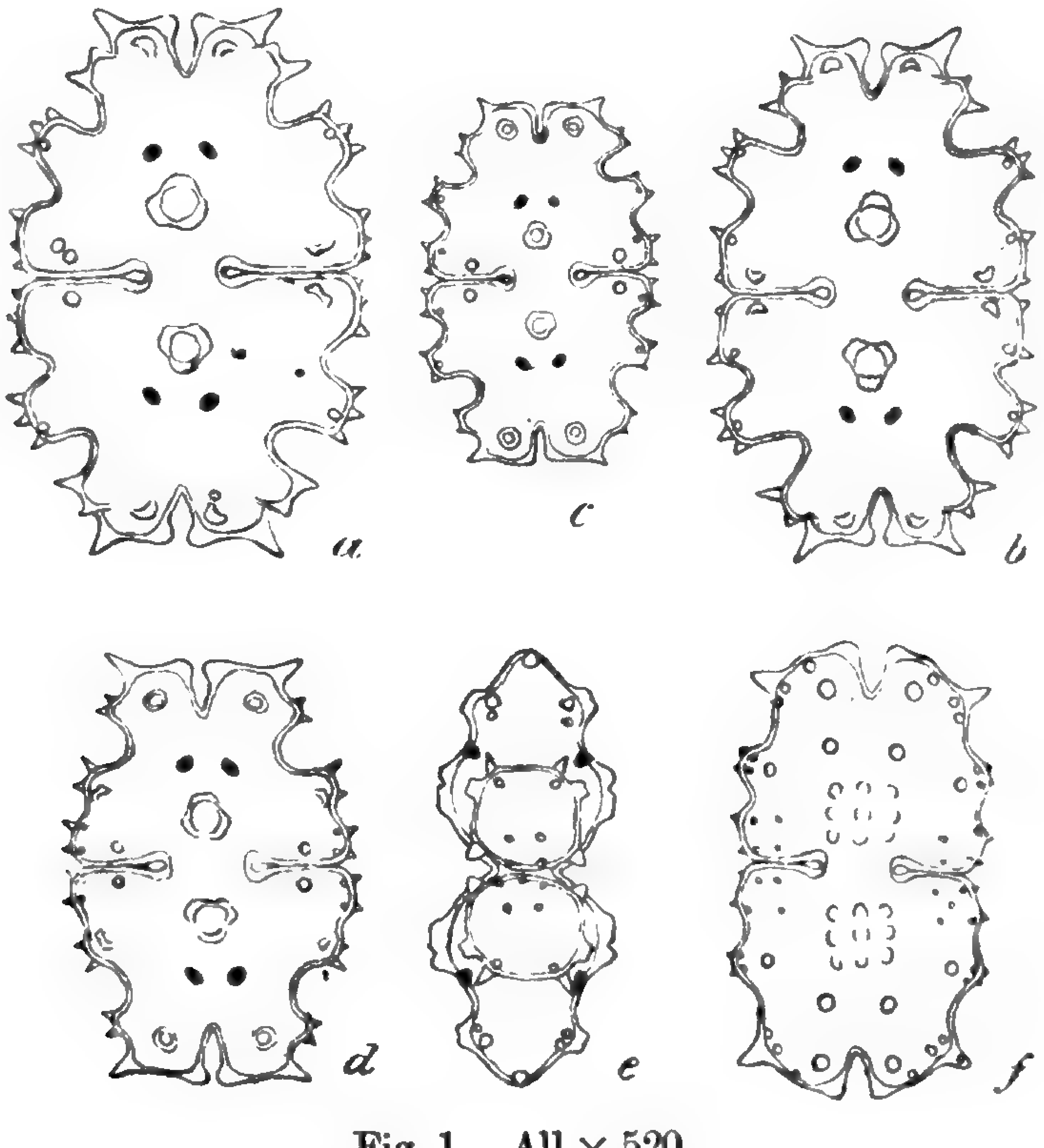

Fig. 1.—All × 520.

a et *b*. *Euastrum evolutum*, West & G. S. West.
c. " " " forma *minor*.
d et *e*. " " " var. *integrius*, West & G. S. West.
f. " *pictum*, Börg., var. *subrectangulare*, n. var.

* In Nordstedt's Index Desmid. (1896), p. 234, *E. coronatum* is placed as a synonym of *E. simplex*, Wolle; we cannot quite comprehend how such an obvious mistake arose.

In 1890 Börgesen described two new species of *Euastrum* from Brazil, *E. incudiforme* and *E. Glaziovii.* These two species we must consider as merely varieties of *E. evolutum*, after examining forms which are certainly intermediate between them and the latter species. We give a figure of one of the transitory forms between the type and var. *Glaziovii* (Pl. **16**. fig. 11).

E. Nordstedtianum var. *elegans*, W. B. Turner (in K. Sv. Vet.-Akad. Handl., Bd. xxv. no. 5, p. 85, t. 11. f. 17), if correctly described with "semicellulæ tumoribus 9 (6 margine, 2 subapice, et 1 grandis centrali parte dispositis) ornatæ," must belong to some other species and not to *E. evolutum.* Also *E. micracanthum*, W. B. Turn. (l. c. p. 82, t. 10. f. 33) may belong here, but again if "tumoribus 8 (4 lateralibus, 2 apicalibus et 2 lobum polarem versus) ornatæ" be correct, it must be relegated elsewhere.

The following are the varieties of this species:—

Forma MINOR. (Fig. xylogr. 1 *c*.)—E. Nordstedtianum var. minor, *Wolle, Desm. U. S.* p. 106, pl. 26. f. 8.

Long 47 μ; lat. 30 μ; lat. isthm. 8 μ.

Hab. Minneapolis, Minnesota; Orono, Maine; Harvey Lake, Pennsylvania, &c.

Var. INCUDIFORME, *nob.*—E. incudiforme, *Börgesen, in Vidensk. Medd. Foren. Kjöbenh.* 1890 (1891), p. 940, t. 3. f. 22.

Var. lobis lateralibus cum spinis paucioribus; lobo polari obverse triangulari, marginibus lateralibus glabris, angulis in spina valida productis, apice truncato cum denticulis paucis.

Börgesen's dimensions are:—Long. 55 μ; lat. 39 μ; lat. isthm. 7·5 μ; crass. 24 μ.

Hab. Brazil.

Var. GUIANENSE, *nob.*—E. Glaziovii, *Börg.*, var. guianense, *Racib. in Flora*, lxxxi. (1895), p. 33, t. 4. f. 19.

Var. lobo polari subrectangulari, angulis apicalibus cum spina valida, apice convexo.

Raciborski's dimensions are:—Long. 42 μ; lat. 23 μ; lat. isthm. 5 μ; crass. 20 μ.

Hab. Tapakoomasee, British Guiana.

Raciborski's figure appears to us somewhat crude, but we have no doubt that it is a form of *E. evolutum*.

Var. GLAZIOVII, *nob.*—E. Glaziovii, *Börgesen, l. c.* p. 941, t. 3. f. 23.

Var. lobis lateralibus subconfluentibus cum spinis minoribus

paucioribusque; lobo polari latiori et apice convexo, marginibus lateralibus cum spina singula præditis.

Börgesen's dimensions are:—Long. 55 μ; lat. 35 μ; lat. isthm. 6·5 μ; crass. 21 μ.

Hab. Brazil.

This differs from var. *integrius* in its more rectangular lateral lobes, the lateral margins of which are even slightly divergent; the apex of the polar lobe is also much more convex.

Var. INTEGRIUS, *West & G. S. West*, *Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 244, pl. 14. ff. 23–25. — E. spinosum, *Wolle*, *Desm. U. S.* p. 106, pl. 27. ff. 4–7, 17 (1884), *non* E. spinosum, *Ralfs* (1844).

Var. lobo polari cum spina singula (vel spinulis binis) utrobique infra spinam majorem, incisura infra lobum polarem majore et latiore, lobis lateralibus non divisis sed subretusis, quadridenticulatis.

Long. 52–61 μ; lat. 32·5–41 μ; lat. isthm. 9·5–10 μ; lat. lob. polar. 24–30 μ; crass. 22–27 μ. (Fig. xylogr. 1 *d* et *e*.)

Hab. Minneapolis, Minnesota; De Land, Florida; Bridgeport, Conn.; Harvey Lake, Pa.

E. clavatum, W. B. Turn. (l. c. p. 85, t. 11. f. 18), may be a form of this variety, but it is insufficiently described and figured, and must therefore be held as doubtful.

54. EUASTRUM PICTUM, *Börgesen, l. c.* p. 939, t. 3. f. 19.

Var. SUBRECTANGULARE, n. var. (Fig. xylogr. 1 *f*.)

Var. minor, semicellulis in parte inferiore subrectangularibus, angulis basalibus leviter divergentibus, sub lobum polarem minus constrictis, in centro cum seriebus verticalibus tribus granulorum, supra ea granulis magnis duobus positis, et granulo magno singulo juxta incisuram apicalem utrobique, etiam granulis nonnullis minoribus intra margines.

Long. 59 μ; lat. 35 μ; lat. lob. polar. (c. spin. apical.) 33 μ; lat. isthm. 9·5 μ.

Hab. Malaga, New Jersey.

55. E. OCCIDENTALE, n. sp.

E. verrucosum, Ehrenb., var. *simplex*, Joshua, in Journ. Bot. (1885), xxiii. p. 34, t. 254. f. 2; West, in Journ. Roy. Micr. Soc. 1890, p. 287. *E. verrucosum*, var. *simplex* forma *tumescens*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, p. 74, t. 11. f. 9*. *Cosmarium protractum*, Wolle, Desm. U. S. p. 83, pl. 17. ff. 27, 28; non *C. protractum*, De Bary.

Euastrum mediocre, circiter $1\frac{1}{3}$-plo longius quam latum, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ truncato-pyramidatæ, angulis basalibus latissime rotundatis, lateribus superioribus retusis, apicibus late truncatis retusisque, angulis superioribus rotundatis; a latere visæ truncato-ovatæ apice retuso; a vertice visæ ellipticæ, polis acute rotundatis, ad medium utrobique leviter sed late inflatæ; membrana granulata, granulis numerosis subconcentrice ordinatis.

Long. 65–85 μ; lat. 60–71 μ; lat. apic. 27–33 μ; crass. 42 μ.

Hab. Near Orono, Maine. Ponds, Pennsylvania. Evanston, Ill. (H. J. no. 80). Waverly, Mass. (H. J. no. 21).

Distrib. Canada and North Wales.

After examining large numbers of this species from various localities and finding its characters quite constant, we are now convinced that it is certainly distinct from *E. verrucosum*, under which species Joshua placed it as a variety. *Cosmarium protractum*, Wolle (l. c.), also evidently belongs to this species. Joshua's figure is more accurate in outline than that of Wolle, but shows too few granules. The specific name '*simplex*' could not be adopted as this name has already been given to two species of this genus.

56. E. VERRUCOSUM, *Ehrenb.*; *Ralfs, Brit. Desm.* p. 79, t. 11. f. 2.

Var. ALATUM, *Wolle, Desm. U. S.* p. 101, t. 26. f. 4.

Hab. Baton Rouge, Louisiana (H. J. no. 321).

Var. REDUCTUM, *Nordst. in Act. Univers. Lund.* xvi. p. 9, t. 1. f. 14.

Long. 64 μ; lat. 60 μ.

Hab. Wake Forest, New Connecticut (H. J. no. 529).

XII. MICRASTERIAS, *Ag.*

57. M. ARCUATA, *Bail. in Smithson. Contrib.* ii. *Art.* 8, p. 37, t. 1. f. 6 (1851); *Nordst. in Öfvers. K. Vet.-Akad. Förh.* no. 3 (1877), p. 22–23 cum fig. xylogr. II. 1, 2 *c*.

Var. GRACILIS, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 238, pl. 13. f. 27.

Long. 73 μ; lat. 121 μ; lat. isthm. 10 μ.

Hab. De Land, Florida.

58. M. PINNATIFIDA, *Ralfs, Brit. Desm.* p. 77, t. 10. f. 3.—Euastrum pinnatifidum, *Kütz.*

A form with an extra basal tooth; lat. 60 μ; *cfr.* West in Journ. Linn. Soc., Bot. xxix. p. 133, t. 20. f. 9.

Hab. Seattle, Wash.

59. MICRASTERIAS FURCATA, *Ralfs, Brit. Desm.* p. 73, t. 9. f. 2 (1848).—M. pseudofurcata, *Wolle,* 1881; *Desm. U. S.* p. 111, t. 35. f. 4.—M. furcata var. decurta, *W. B. Turn. in Journ. Roy. Micr. Soc.* 1885, p. 936, t. 16. f. 10.—M. furcata var. simplex, *Wolle,* 1885; *Alg. U. S.* p. 40, t. 59. ff. 6–7.

Hab. De Land, Florida. "Found it abundant in material collected in 1895. All forms were present, from typical ones to those with the lateral arms undivided. A specimen showing one-half of the '*pseudofurcata*' type and the other half of the simplest is preserved in H. J. no. 560. Diam. of simplest part 196 μ, of other 144 μ." (Fig. xylogr. 2 *b.*)

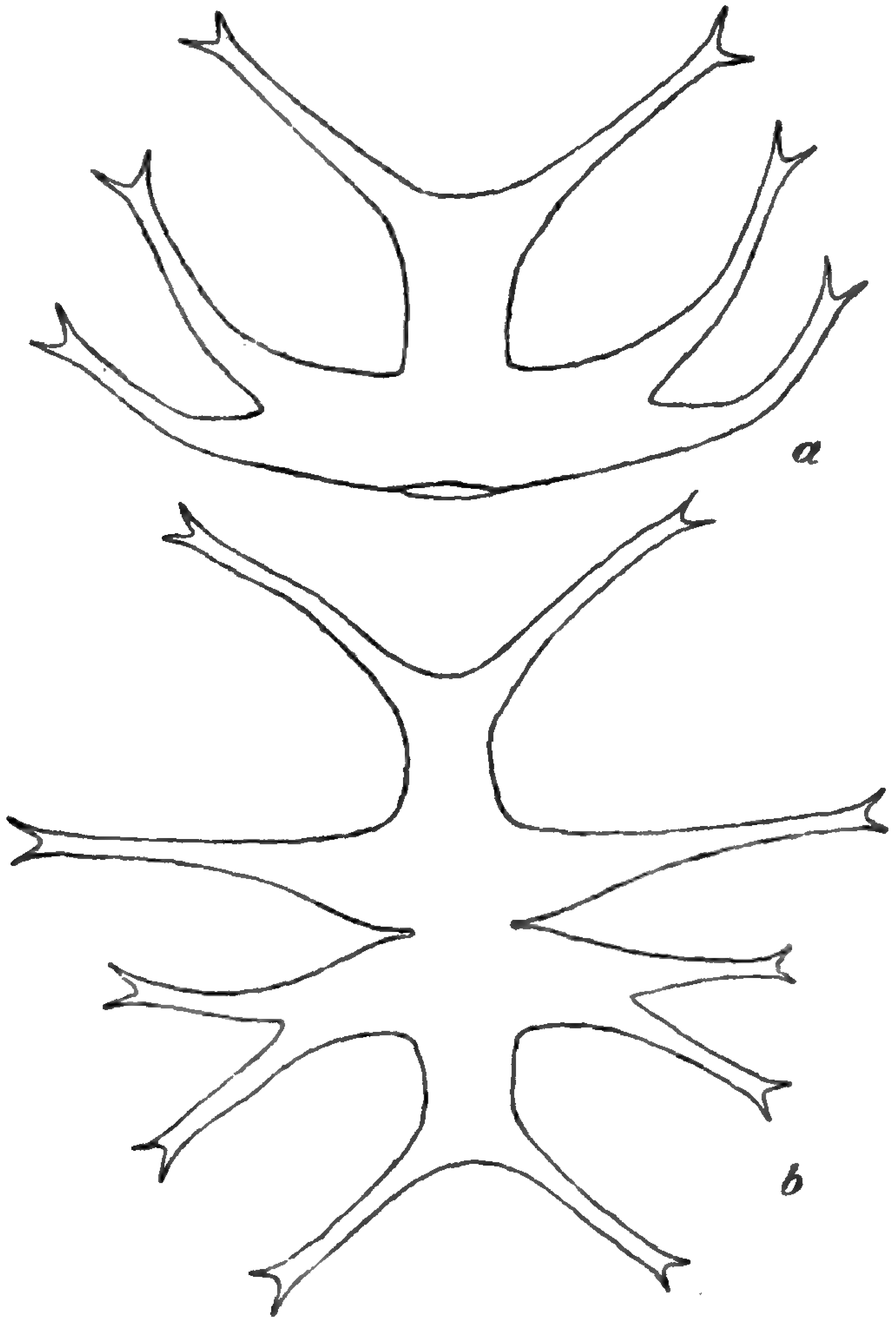

Fig. 2.—*Micrasterias furcata,* Ralfs. *a* et *b,* ×340.

Specimen of '*pseudofurcata*' form in H. J. no. 573 (lat. 185 μ).

"Found several curious specimens having the lateral rays recurved strongly, and in one case with the apices blunt." (Fig. xylogr. 2 *a*.)

Seattle, Wash. Mostly typical and rather small (lat. 120 μ).

60. MICRASTERIAS RINGENS, *Bail.* 1851; *Wolle, Desm. U.S.* p. 112, t. 35. ff. 1, 2.

Var. SERRATULA, *Wolle,* 1885; *Alg. U. S.* p. 41, t. 59. f. 15.

The specimens are referred to *M. ringens* with some doubt. In the two specimens observed the margins were serrate as in *M. mahabuleshwarensis*, and the apices of the lobes possessed three teeth; also they had each a basal granulate protuberance to the semicells. One specimen (long. 145 μ; lat. 116 μ; lat. isthm. 21 μ) possessed a series of granules within the serrate margin, whereas the other (Laconia, N.H., H. J. nos. 650 and 679; long. 156 μ; lat. 152 μ) was quite smooth. These forms appear to differ from many specimens of *M. mahabuleshwarensis* that we have seen only in the absence of the additional apical process.

61. M. AMERICANA, *Ralfs, Brit. Desm.* p. xix et 74, t. 10. f. 1 *a–c* (1848).—Euastrum americanum, *Ehrenb.* 1843.

Var. LEWISIANA, *West, in Journ. Roy. Micr. Soc.* 1890, p. 286, t. 5. f. 13.

Long. 80–103 μ; lat. 70–84 μ; lat. isthm. 23–26 μ.

Hab. Ithaca, N.Y. (H. J. nos. 491 & 493).

62. M. TORREYI, *Bail. in Ralfs, Brit. Desm.* p. 210, t. 35. f. 5; *Wolle, Desm. U. S.* p. 108, t. 30. ff. 1–8.

Hab. De Land, Florida (H. J. nos. 604 & 617).

63. M. SPECIOSA, *Wolle,* 1885; *Alg. U. S.* p. 38, t. 56. ff. 1, 2; *West & G. S. West in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 240.

Long. 104 μ; lat. 96 μ.

Hab. De Land, Florida (H. J. no. 561).

64. M. TETRAPTERA, n. sp. (Pl. **16**. fig. 6.)

M. submediocris, paullo longior quam lata, elliptica, apicibus late truncatis, profundissime constricta, sinu lineari; semicellulæ quinquelobæ, incisuris subampliatis; lobo polari subinfundibuliformi, ejus angulis lateraliter productis et decurvatis, apice con-

vexo et late retuso; lobis lateralibus subinæqualibus (superioribus majoribus) cum incisuris primariis tribus, ea mediana profundiori, in lobo inferiori lobulis emarginatis, in lobo superiori lobulis divisis cum partibus emarginatis; marginibus sinuum et incisurarum subpolarium denticulo (circ. 5) regulariter ordinatis intra margines ferentibus.

Long. 116 μ; lat. 100 μ; lat. apic. lob. polar. 56 μ; lat. isthm. 16 μ.

Hab. Tallahassee, Florida (H. J. no. 546).

In the division of its lateral lobes and also in the possession of the small teeth bordering the margins of the sinus and subpolar incisions, this species most nearly approaches *M. speciosa*, Wolle, but the ultimate lobules are more numerous, emarginate and not sharply apiculate as in the latter species; the polar lobe is also quite different in form.

Dr. Nordstedt (in letter to Johnson) expressed the opinion that it was nearest *M. conferta*, Lund., var. *hamata*, Wolle. We think, however, that the decided inequality of the superior and inferior lateral lobes, and the marginal denticulations of the median and subpolar incisions, are characters more in affinity with *M. speciosa*; moreover, the polar lobe *gradually* widens from base to apex and the latter is destitute of teeth.

The outward form of *M. tetraptera* is different from that of either *M. speciosa* or *M. conferta* var. *hamata*.

65. MICRASTERIAS FOLIACEA, *Bail. in Ralfs, Brit. Desm.* p. 210, t. 35. f. 3; *Johnson, in Bot. Gaz.* xix. p. 56, t. 6. ff. 1–4.

Long. 80 μ; lat. 85 μ.

Hab. Laconia, N.H.; rather scarce in a pond on the stream flowing from Lake Winnepesaukee (H. J. no. 665).

66. M. APICULATA, *Menegh.* 1840; *Cooke, Brit. Desm.* p. 186, pl. 48. f. 1 (after W. B. Turner).

Lat. 220 μ.

Hab. De Land, Florida (H. J. no. 572).

67. M. JOHNSONII, n. sp. (Pl. **16**. fig. 5.)

M. magna, circiter tam longa quam lata, profundissime constricta, lateralibus sinus sigmoideo-sinuatis; semicellulæ profunde quinquelobæ, incisuris extrorsum ampliatis; lobo polari angusto et elongato, lateribus subparallelis sed apicem versus divergentibus, apice late bifido, angulo unoquoque acuto et in spinam longam producto; lobis lateralibus subcampanulatis et

profunde fissis, lobulis divergentibus sursum angustatis cum apicibus profunde bifurcatis, angulo unoquoque in spinam longam producto; semicellulis intra marginem lobi uniuscujusque serie spinarum minutarum confertarum instructis.

Long. 270 μ; lat. 275 μ; lat. bas. lob. polar. 26 μ; lat. isthm. 30 μ.

Hab. De Land, Florida (H. J. no. 580).

This is a very distinct species and cannot be well confounded with any other.

68. MICRASTERIAS CRENATA, *Bréb. in Ralfs, Brit. Desm.* p. 75, t. 7. f. 2, t. 10. f. 4.

Lat. 76 μ.

Hab. Wake Forest, New Connecticut, occasional (H. J. no. 530).

XIII. XANTHIDIUM, *Ehrenb.*

69. X. ANTILOPŒUM, *Kütz.* (1849).—Cosmarium antilopœum, *Bréb.* (1840).—Xanthidium fasciculatum, *Ralfs, Brit. Desm.* (ex parte) t. 20. f. 1 *a*, *c*.

Var. MINNEAPOLIENSE, *Wolle*, 1884.

A form with the spines nearly half as long as the body and very slender; in the centre of the semicells are two or three semicircles of granules, and "just below these on each face arises a long slender spine which stands out *widely*. This is not at all like other specimens placed here, yet agrees in essential features."

Long. c. spin. 138 μ, s. spin. 72 μ; lat. c. spin. 126 μ, s. spin. 64 μ; long. spin. 35 μ; lat. isthm. 20 μ; crass. s. spin. 48 μ.

Hab. De Land, Florida (H. J. no. 570).

70. X. CONTROVERSUM, n. sp. (Pl. 17. fig. 2.)

X. antilopœum? var., *West & G. S. West, in Trans. Linn. Soc.*, Ser. II. (*Bot.*), v. p. 252, pl. 16. f. 1.

X. parvum, $1\frac{1}{5}$-plo longius quam latum (sine spinis), profunde constrictum, sinu acutangulo subaperto; semicellulæ hexagono-ellipticæ, angulis lateralibus et apicalibus spina curvata singula (vel nonnunquam spinis geminatis) præditis, spinis omnibus sursum divergentibus; a latere visæ globosæ; a vertice visæ ellipticæ; membrana minute punctata, in centro semicellularum levissime incrassata.

Long. c. spin. 55–59 μ, s. spin. 36·5–38 μ; lat. c. spin. 52–56 μ, s. spin. 31 μ; lat. isthm. 7·6–8 μ; crass. 20–21 μ.

Hab. Laconia, N.H. (H. J. no. 660).

There is no doubt that Johnson has observed the same plant that we doubtfully placed as a form of *X. antilopæum.* All the specimens seen by him had only single spines at the angles, whereas many of our examples had a pair of spines at one or more of the angles. It is a much smaller species than *X. antilopæum*, and although the form of the semicells is about the same, yet the spines have the same direction as the paired spines of *X. cristatum*; moreover *X. antilopæum* never has single spines at its angles. The forms of this species may be regarded as intermediate between *X. inchoatum*, Nordst., and *X. antilopæum.*

71. Xanthidium hastiferum, *W. B. Turn. in Journ. Roy. Micr. Soc.* 1885, p. 938, t. 15. f. 20.—X. antilopœum var. angulatum, *Josh. in Journ. Linn. Soc., Bot.* xxi. (1886) p. 643, t. 24. f. 16.—X. angulatum, *Lagerh.* (1887).

Var. Johnsonii, n. var.

X. antilopæum, forma *javanicum,* Johnson, Bull. Torr. Bot. Club, xxii. (1895), no. 7. p. 295, pl. 239. f. 10; non *X. antilopæum* forma *javanica,* Nordst. 1880 (= *X. hastiferum* var. *javanicum,* W. B. Turn. 1892).

Var. spinis brevioribus et quasi uniformibus, spinis apicalibus singulis vel geminatis; serie curvata granulorum 8 infra apicem semicellularum.

Long. c. spin. 64 μ, s. spin. 52 μ; lat. c. spin. 80 μ, s. spin. 52 μ; lat. isthm. 12 μ; crass. 30 μ.

Hab. Ann Arbor, Mich. (H. J. no. 324).

72. X. Johnsonii, n. sp. (Pl. **17**. fig. 1.)

X. minutissimum, tam longum quam latum (sine spinis), profunde constrictum, sinu acuto extrorsum ampliato; semicellulæ hexagono-ellipticæ, angulis lateralibus spina longa tenui singula, angulis superioribus spinis binis similibus, etiam spinis binis ad marginem inferiorem prope basin semicellularum, in centro spinis duabus planitie verticali dispositis; a latere visæ subcirculares, spinis duabus divergentibus prope apicem, spinis geminatis divaricatis ad medium utrobique; a vertice visæ ellipticæ, spinis tribus divergentibus ad polum unumquemque, spina singula ad medium utrobique.

Long. c. spin. 23 μ, s. spin. 11 μ; lat. c. spin. 23 μ, s. spin. 11 μ; lat. isthm. 5 μ; crass. c. spin. 18 μ, s. spin. 6 μ.

Hab. Bridgeport, Conn. (H. J. no. 517).

73. Xanthidium Torreyi, *Wolle*, 1885; *Alg. U. S.* p. 35, t. 56. ff. 13, 14.

Long. c. spin. 80–92 μ; long. s. spin. 38–42 μ; lat. c. spin. 86–92 μ, s. spin. 34–40 μ; long. spin. 25–29 μ; crass. bas. spin. 2–3·5 μ; lat. isthm. 15 μ.

Hab. De Land, Florida (H. J. nos. 577 & 588).

"In the vertical view it is distinctly inflated in the centre."

74. X. armatum, *Rabenh.* 1847; *Ralfs, Brit. Desm.* p. 112, t. 18.—Cosmarium armatum, *Bréb.* 1840.

Var. cervicorne, n. var. (Fig. xylogr. 3.)

Var. major, processibus multo longioribus, irregulariter et subdichotome ramosis, spinis multo longioribus et acutioribus.

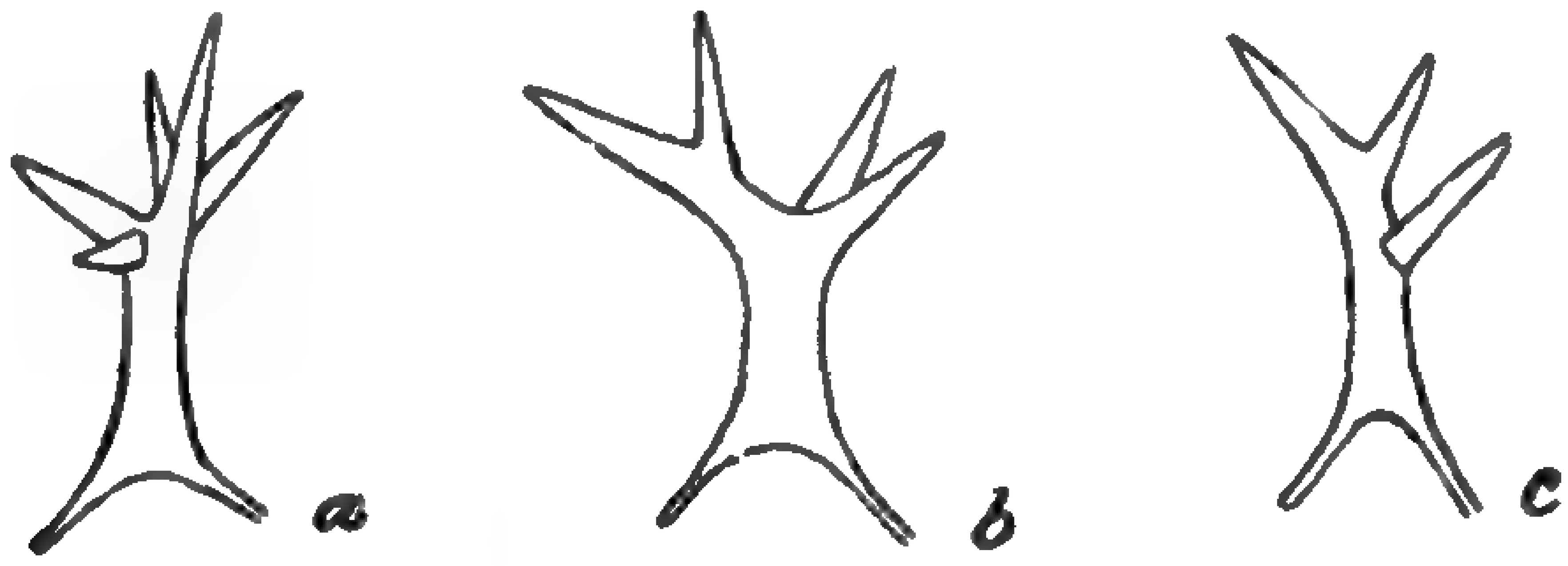

Fig. 3.—*Xanthidium armatum*, Rabenh., var. *cervicorne*, n. var. Three of the processes. ×520.

Hab. De Land, Florida.

This variety is the "finely developed form" mentioned by Wolle (Desm. U. S. p. 92, pl. 21. f. 1) from Mt. Everett, Mass.; his figure, however, is very inaccurate with regard to the processes and spines.

XIV. COSMARIUM, *Corda*.

75. C. retusiforme, *Gutw. in Bot. Centralbl.* xliii. p. 69.—C. Hammeri, *Reinsch*, var. retusiforme, *Wille, in Vid.-Selsk. Forh. Christiania*, no. 11, p. 32, t. 1. f. 16.

Long. 21 μ; lat. 18 μ.

Hab. New Baltimore, Mich., occasional.

76. C. holmiense, *Lund. in Nov. Act. R. Soc. Scient. Ups.* Ser. III. viii. no. 2, p. 49, t. 2. f. 20.

Var. integrum, *Lund. l. c.*

Long. 45–54 μ; lat. 28–34 μ.

Hab. Ithaca, N.Y. (H. J. no. 511).

77. Cosmarium Baileyi, *Wolle, Desm. U.S.* p. 64, pl. 16. ff. 17, 18.

Var. major, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 246, pl. 14. f. 36.

Long. 70–80 μ; lat. 70 μ; crass. 32 μ.

Hab. Tallahassee, Florida (H. J. nos. 549 & 550).

78. C. pachydermum, *Lund. in Act. R. Soc. Scient. Ups.* Ser. III. ii. p. 39, t. 2. f. 15.

Var. minus, *Nordst. in Act. Univ. Lund,* ix. (1873), p. 18, t. 1. f. 7.

Long. 46–52 μ; lat. 40–44 μ; lat. isthm. 12 μ.

Hab. Cold Spring Harbour, N.Y., frequent (H. J. no. 153). De Land, Florida (H. J. no. 581).

The examples were a little smaller than the Norwegian ones, and proportionately shorter; membrane strongly punctate. It approaches the *Cosmarium* mentioned by Nordstedt (in K. Sv. Vet.-Akad. Handl., Bd. xxii. no. 8, p. 54, t. 5. f. 22), but is a little smaller and is also more deeply constricted.

79. C. capense, *De Toni, Syll. Algar.* p. 969.—C. pyramidatum subsp. capense, *Nordst. in Act. Univ. Lund.* xvi. (1880), p. 6, t. 1. f. 8.

Forma minor et isthmo latiori; long. 64 μ; lat. 46 μ; lat. isthm. 16 μ. (Pl. **17**. fig. 3.)

Hab. Whitmore Lake, Mich. (H. J. no. 436).

80. C. perforatum, *Lund. l. c.* p. 40, t. 2. f. 16.

Long. 61 μ; lat. 57 μ; lat. isthm. 34 μ.

Hab. Plymouth and Laconia, N.H., scarce (H. J. nos. 645 & 646). Harvey Lake, Pennsylvania, frequent.

81. C. ocellatum, *B. Eichler et Gutw. in Rosprawy. Akad. Umiej. Krakow. Wydzial. nat.-przyr.* xxviii. (1894), p. 164, t. 4. f. 7.

Var. americanum, n. var.

Var. longior, semicellulis cum lateribus levissime retusis et apicibus subtruncatis, in centro incrassatis; a vertice visis ellipticis, incrassatis et late tumidis ad medium utrobique, tumore unoquoque leviter retuso.

Long. 29 μ; lat. 24 μ; lat. isthm. 5·7 μ; crass. 13 μ.

This variety differs from *C. ocellatum* var. *incrassatum* in its

proportionately longer cells, its somewhat retuse lateral margins, and in the more emarginate thickening in the centre of the semi-cells, which is also devoid of scrobiculation.

82. COSMARIUM ANGULARE, *Johnson, in Bull. Torr. Bot. Club*, xxi. (1894), no. 7, p. 290, pl. 211. f. 14.

Long. 30 μ; lat. 25 μ.

Hab. Baton Rouge, La., scarce.

83. C. RECTANGULARE, *Grun. in Rabenh. Flor. Europ. Alg.* iii. p. 166 (1868).—C. gotlandicum, *Wittr.* (1872).

Long. 38 μ; lat. 30 μ; lat. isthm. 10 μ; crass. 18 μ.

Hab. Laconia, N.H., occasional.

84. C. LUNATUM, *Wolle, Desm. U. S.* p. 65, pl. 16. f. 16.

Var. DEPRESSUM, n. var. (Pl. **18.** figs. 2, 3.)

Var. cellulis circiter 1½-plo latioribus quam longis, apicibus depressis, sinu angustiori et apice acuto; pyrenoidibus singulis.

Long. 20–22 μ; lat. 30–31 μ; lat. isthm. 6–7 μ.

Hab. Tallahassee, Florida (H. J. no. 551).

85. C. SINOSTEGOS, *Schaarschm. in Magyar. Tudom. Akad. Math. s. Termész. Közlem.* xviii. p. 266, t. 1. f. 12.

Long. 10 μ; lat. 10 μ; crass. 5 μ.

Hab. Seattle, Wash., frequent.

Var. OBTUSIUS, *Gutw. in Nuov. Notarisia*, iii. p. 21.

Long. 10 μ; lat. 8 μ; lat. isthm. 3 μ; crass. 4 μ.

Hab. Laconia, N.H., occasional.

86. C. PYGMÆUM, *Arch. in Quart. Journ. Micr. Sci.* 1864, p. 174, pl. 6. ff. 45–49; *West in Journ. Linn. Soc. (Bot.)*, xxix. p. 146, pl. 20. f. 24.

Var. SCHLIEPHACKIANUM, *nob.*—C. Schliephackianum, *Grun. in Rabenh. Flor. Europ. Alg.* iii. p. 167 (1868).

Var. semicellulis a vertice visis tumore prominentiori utrobique instructis.

Long. 12 μ; lat. 10–12 μ; lat. isthm. 3·5–5 μ.

Hab. Bridgeport, Conn., and New Baltimore, Mich., common; Laconia, N.H., occasional.

Grunow's species appears to us to differ from *C. pygmæum*, Arch., only in the more prominent central protuberance, and cannot therefore stand as a distinct species. In vertical view *C. pygmæum* is subrhomboidal, with a faint indication of a central

inflation. The breadth of the isthmus in var. *Schliephackianum* is somewhat variable.

87. COSMARIUM EXIGUUM, *Arch. in Proc. Dubl. Nat. Hist. Soc.* 1864, p. 49, pl. 1. ff. 32–33; *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 58, t. 6. f. 12 (1888).

Forma major, semicellulis rotundatioribus; long. 41 μ; lat. 24 μ; lat. isthm. 9 μ.

Hab. Whitmore Lake, Mich. (H. J. no. 559 *a*).

Forma angulis basalibus rectangularibus et sinu angusto lineari; long. 17 μ; lat. 10 μ; lat. isthm. 4 μ; crass. 6 μ. (Pl. 16. fig. 15.)

Hab. Florida.

88. C. REGNELLII, *Wille*, var. MADAGASCARIENSE, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 58, pl. 6. f. 39.

Long. 17 μ; lat. 19 μ; lat. isthm. 4 μ.

Hab. De Land, Florida.

89. C. DIFFICILE, *Lütkem. in Verhandl. d. k.k. zool.-botan. Ges. Wien,* xlii. (1892) p. 551, t. 8. f. 3.

Long. 31 μ; lat. 20 μ; lat. isthm. 6 μ.

Hab. Harvey Lake, Pennsylvania.

90. C. REPANDUM, *Nordst. in Botan. Notiser,* 1887, p. 162; *in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 58, t. 6. f. 14 (1888).

Forma MINOR.—C. odontopleurum, *Arch. in Ann. Scott. Nat. Hist.* (1894), p. 169, t. 2. f. 13.

Long. 15–17 μ; lat. 14–15·5 μ; lat. isthm. 5·5 μ.

Hab. Harvey Lake, Pennsylvania.

(*Cfr.* Borge, in Nuova Notarisia, 1896, p. 57; and West & G. S. West, in Journ. Bot. xxxv. (1897) p. 120.)

91. C. REGNESII, *Reinsch, in Abhandl. Naturhistor. Gesellsch. Nürnberg,* Bd. iii. p. 112, t. 7. f. 8.

Long. 12 μ; lat. 12 μ; lat. isthm. 5 μ; crass. 5 μ.

Hab. Laconia, N.H.

92. C. BIOCULATUM, *Menegh.*; *Ralfs, Brit. Desm.* p. 95, t. 15. f. 5.

Var. DEPRESSUM, *Schaarschm. in Magyar. Tudom. Akad. Math. s. Termész. Közlem.* xviii. (1882) p. 270, t. 1. f. 10.

Long. 11·5–15 μ; lat. 12·5–17 μ; lat. isthm. 3–4·5 μ.

Hab. Harvey Lake, Pennsylvania.

93. COSMARIUM SUBCRENATUM, *Hantzsch*, 1861; *Nordst. in Öfvers. K. Vet.-Akad. Förh.* 1875, no. 6, p. 21, t. 6. ff. 10, 11.

"Zygospores spherical, about 32–35 μ in diameter, clothed with scattered spines 8–10 μ long suddenly rising from a conical base, apices slightly furcate."

Hab. Arlington, Mass. (H. J. nos. 68 & 71).

94. C. TUMENS, *Nordst. in Ofvers. K. Vet.-Akad. Förh.* 1872, no. 6, p. 36, t. 7. f. 23.

Var. GLABRUM, n. var.

Var. cellulis glabris, granulis nullis.

Long. 52 μ; lat. 35 μ; lat. isthm. 24 μ; crass. 30 μ.

Hab. Wyoming, Pa. (H. J. no. 457).

95. C. ROSTAFINSKII, *Gutw.* 1890; *in Sprawozd. fizyjogr. Akad. Umiej. Krakow.* xxvii. (1892) p. 67, t. 3. f. 16.

Var. AMERICANUM, n. var. (Pl. **17**. fig. 13.)

Var. semicellulis apicibus truncatis, supra isthmum glabris; a vertice visis tumore glabro utrobique.

Long. 32 μ; lat. 24 μ; lat. isthm. 11 μ; crass. 16 μ.

Hab. Palo Alto, Calif. (H. J. no. 558).

96. C. MODESTUM, n. sp. (Pl. **17**. fig. 12.)

C. parvum, circiter 1¼-plo longius quam latum, profundissime constrictum, sinu angusto-lineari; semicellulæ pyramidato-trapeziformes, angulis basalibus rectangularibus, lateribus convexis cum crenis 4, iis apices versus majoribus et truncatis (vel levissime emarginatis), apicibus truncatis rectisque, intra crenas et apicem cum granulis minimis indistinctis concentricis et radiantibus; a latere visæ late ovatæ; a vertice visæ ellipticæ cum tumore lato utrobique; pyrenoidibus singulis.

Long. 33 μ; lat. 26 μ; lat. isthm. 7 μ; crass. 17 μ.

Hab. Whitmore Lake, Mich. (H. J. no. 439).

Compare with *C. costatum*, Nordst., and *C. aphanichondrum*, Nordst.

97. C. POLYMORPHUM, *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* 1869, nos. 14–15, p. 209, t. 3. f. 31.

Long. 36 μ; lat. 28 μ; lat. isthm. 7 μ; crass. 20 μ.

Hab. De Land, Florida (H. J. no. 611).

98. Cosmarium Raciborskii, *Lagerh. in Öfvers. K. Sv. Vet.-Akad. Förh.* 1887, no. 8, p. 537.—C. Nordstedtii, *Racib.* 1884.

Long. 48 μ; lat. 53 μ; lat. isthm. 20 μ.

Hab. Laconia, N.H., occasional.

99. C. monomazum, *Lund. in Nov. Act. Soc. Scient. Ups.* Ser. III. vol. viii. no. ii. p. 32, t. 7. f. 11.

Var. tristichum, n. var. (Fig. xylogr. 4.)

Var. granulis 9 in centro semicellularum in seriebus transversis 3 ordinatis.

Long. 32 μ; lat. 36 μ; lat. isthm. 11 μ; crass. 20 μ.

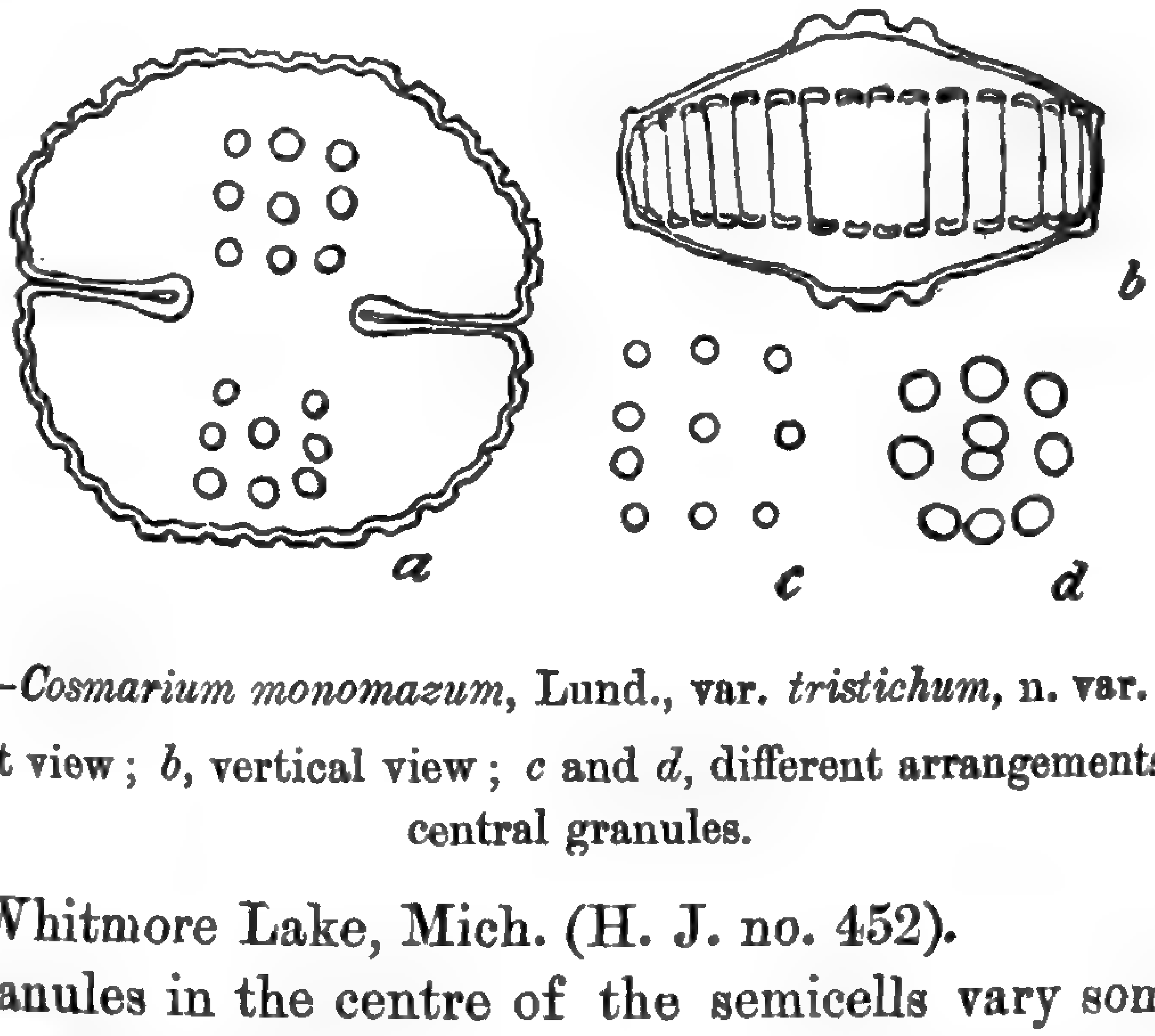

Fig. 4.—*Cosmarium monomazum*, Lund., var. *tristichum*, n. var. ×750.
a, front view; *b*, vertical view; *c* and *d*, different arrangements of the central granules.

Hab. Whitmore Lake, Mich. (H. J. no. 452).

The granules in the centre of the semicells vary somewhat in number and arrangement; the central one or one of the outer ones may be doubled, or the middle one of the basal row may be wanting.

100. C. taxichondrum, *Lund. l. c.* p. 39, t. 2. f. 13.

Var. bidentulum, *Lagerh. in Öfvers. K. Vet.-Akad. Förh.* 1885, no. 7, p. 237, t. 27. f. 8.

Long. 32–34 μ; lat. 30–32 μ; lat. isthm. 8 μ; crass. 16–17 μ.

Hab. Seattle, Wash.

101. C. pseudotaxichondrum, *Nordst. in Öfvers. K. Vet.-Akad. Förh.* 1877, no. 3, p. 20, t. 2. f. 5.

Var. floridense, n. var. (Pl. 18. fig. 1.)

Var. egregia, apicibus semicellularum angustioribus et retusis (angulis apicalibus leviter productis), serie transversi verrucarum

emarginatarum 3 supra basin; cellulis a vertice visis angustioribus, serie verrucarum emarginatarum 3 utrobique (ea mediana majori).

Long. 26–26·5 μ; lat. 33·5–36·5 μ; lat. isthm. 6·5–7·5 μ; crass. 16 μ.

Hab. De Land, Florida.

This is a noteworthy variety; in the front view the warts are seen to be very irregular with regard to their emargination.

102. COSMARIUM SUBNUDICEPS, n. sp. (Pl. 17. fig. 6.)

C. subparvum, $1\frac{1}{3}$-plo longius quam latum, profunde constrictum, sinu lineari; semicellulæ oblongo-ellipticæ, apice recto in medio, cum seriebus horizontalibus 4 granulorum trans medium, seriebus superioribus duabus cum granulis 6, in serie proxima granulis 4, in serie infima granulis 3, cum scrobiculis magnis irregulariter triangularibus inter granulos; a latere visæ subglobosæ cum granulis 4 in parte superiori marginis utrobique; a vertice visæ late ellipticæ.

Long. 44 μ; lat. 34 μ; lat. isthm. 9 μ; crass. 26 μ.

Hab. Laconia, N.H. (H. J. no. 673).

From its nearest ally *C. nudiceps*, Johns., it is distinguished by its elliptical semicells, by the absence of granules at the opening of the sinus, by the less numerous and differently arranged granules across the front of the semicells, and in the subtriangular scrobiculations between these granules. It may also be compared with *C. insigne*, Schmidle.

103. C. COSMETUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 250, pl. 15. f. 4.

Long. 53 μ; lat. 43 μ; lat. isthm. 13 μ; crass. 28 μ. (Pl. 17. fig. 5.)

Hab. Laconia, N.H. (H. J. no. 672).

104. C. LATUM, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg,* iv. p. 128, t. 1. f. 10.

Hab. Edgemoor, Ind. (H. J. no. 116). New Baltimore Mich. Cold Spring Harbour, N.Y. (H. J. no. 148). Meredith, N.H.

105. C. JOHNSONII, n. sp. (Pl. 17. fig. 4.)

C. magnum, $1\frac{1}{2}$-plo longius quam latum, profunde constrictum, sinu lineari extremo ampliato et extrorsum late aperto; semicellulæ

sphærico-ellipticæ, apicibus subdepressis ; a vertice visæ latissime ellipticæ ; membrana granulata, granulis in seriebus verticalibus 20 et horizontalibus 16 regulariter ordinatis.

Long. 104 μ ; lat. 70 μ ; lat. isthm. 28 μ ; crass. 58 μ.

Hab. Florida (H. J. no. 514).

We consider this a very distinct species ; its form, the arrangement of its numerous granules, and its great thickness being very characteristic. The nearest species to it is *C. conspersum*, Ralfs, var. *rotundatum*, Wittr., from which it is easily distinguished by the rounded form of its semicells, its proportionately greater length, its more numerous series of granules, and the form of its vertical view. It might also be compared with *C. latum*, Bréb.

106. COSMARIUM RENIFORME, *Arch. in Journ. Bot.* xii. (1874) p. 92.—C. margaritiferum var. reniformis, *Ralfs.*

Long. 53 μ ; lat. 43 μ ; lat. isthm. 16 μ. (Pl. **17**. fig. 9.)

Hab. New Baltimore, Mich.

Var. COMPRESSUM, *Nordst. in Botan. Notiser*, 1887, p. 159 ; *in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 46, t. 5. f. 5.

Long. 55 μ ; lat. 53 μ ; lat. isthm. 17 μ ; crass. 27 μ. (Pl. **17**. fig. 10.)

Hab. Laconia, N.H. (H. J. no. 661).

Var. ELEVATUM, n. var. (Pl. **17**. fig. 11.)

Var. semicellulis altioribus, diametro pæne $1\frac{1}{2}$-plo longioribus, angulis basalibus subrectangularibus, lateribus in parte inferiori subparallelis.

Long. 52 μ ; lat. 36 μ ; lat. isthm. 14 μ ; crass. 24 μ.

Hab. Whitmore Lake, Mich. (H. J. no. 434).

107. C. NATHORSTII, *Boldt, in Bih. till K. Sv. Vet.-Akad. Handl.* xiii. no. 5, p. 20, t. 1. f. 21.

Long. 53 μ ; lat. 44 μ ; lat. isthm. 12·5 μ.

Hab. New Baltimore, Mich. (H. J. no. 278).

108. C. TURPINII, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg* iv. p. 127, t. 1. f. 11.—C. Turpinii, forma, *Lund.* ; C. Turpinii var. Lundellii, *Gutw.*

Long. 70 μ ; lat. 50 μ ; lat. isthm. 14 μ ; crass. 36 μ.

Hab. Chester, S.C. (H. J. no. 625). Alma, Mich. (H. J. no. 619).

109. COSMARIUM DENTATUM, *Wolle, Desm. U. S.* p. 76, pl. 13. f. 15; *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 249, pl. 15. ff. 10, 11.

Long. 120–130 μ; lat. 84–100 μ.

Hab. Edgemoor, Ind., very scarce (H. J. no. 134). Cold Spring Harbour, N.Y., not very rare in middle pond (H. J. nos. 151 & 172). Bridgeport, Conn. (H. J. no. 20). Whitmore Lake, Mich., not frequent (H. J. no. 465).

110. C. ELOISEANUM, *Wolle, Desm. U. S.* p. 85, pl. 19. ff. 1, 2; *West & G. S. West, l. c.* p. 248, pl. 15. f. 22.

Long. 105 μ; lat. 72 μ; lat. isthm. 34 μ.

Hab. Laconia, N.H., scarce (H. J. no. 641).

111. C. PSEUDAMŒNUM, *Wille, in Bih. till K. Sv. Vet.-Akad. Handl.* viii. no. 18, p. 18, t. 1. f. 37 (1884).—C. inornatum, *Josh.*, 1886.

Var. BASILARE, *Nordst. in Botan. Notiser*, 1887, p. 160; *in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 50, t. 5. f. 14.

Long. 40 μ; lat. 22·5 μ; lat. isthm. 15 μ.

Hab. Malaga, N.J.

112. C. ELEGANTISSIMUM, *Lund. in Act. R. Soc. Scient. Ups.* Ser. III. viii. no. 2, p. 53, t. 3. f. 20.

Var. SIMPLICIUS, n. var. (Pl. 17. fig. 7.)

Var. minor, semicellulis verrucis simplicibus et rotundatis, in seriebus verticalibus 7 (ut visis) et horizontalibus 7 ordinatis.

Long. 55 μ; lat. 22 μ.

Hab. Florida (H. J. no. 345).

113. C. ORDINATUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 251, pl. 15. f. 14.—C. brasiliense, *Nordst.*, subsp. ordinatum, *Börgesen, in Vidensk. Meddel. Foren. Kjöbenh.* 1890 (1891), p. 40, t. 4. f. 32.

Var. DEPRESSUM, n. var. (Pl. 17. fig. 8.)

Var. semicellulis depressis, angulis basalibus rotundioribus, granulis paucioribus et reductis.

Long. 27 μ; lat. 29 μ; lat. isthm. 8 μ; crass. 18 μ.

Hab. De Land, Florida (H. J. no. 632).

114. Cosmarium creperum, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 63, pl. 7. f. 11.

Long. 34 μ; lat. 31 μ; lat. isthm. 13 μ.

Hab. Harvey Lake, Pennsylvania.

The granules are slightly larger than in the original specimens, but otherwise the plants agree in all details.

115. C. spinosporum, *Lagerh. in Öfvers. K. Sv. Vet.-Akad. Förh.* 1887, no. 8, p. 538.—C. Broomii, var., *Wolle, Desm. U. S.* pl. 17. ff. 8, 9.

Hab. Ann Arbor, Mich., abundant and conjugating (H. J. no. 311).

116. C. protractum, *De Bary, Conj.* p. 72.—Euastrum protractum, *Näg.*

Long. 34–36·5 μ; lat. 35–36 μ; lat. apic. 18 μ; lat. isthm. 9·5 μ.

Hab. Harvey Lake, Pennsylvania.

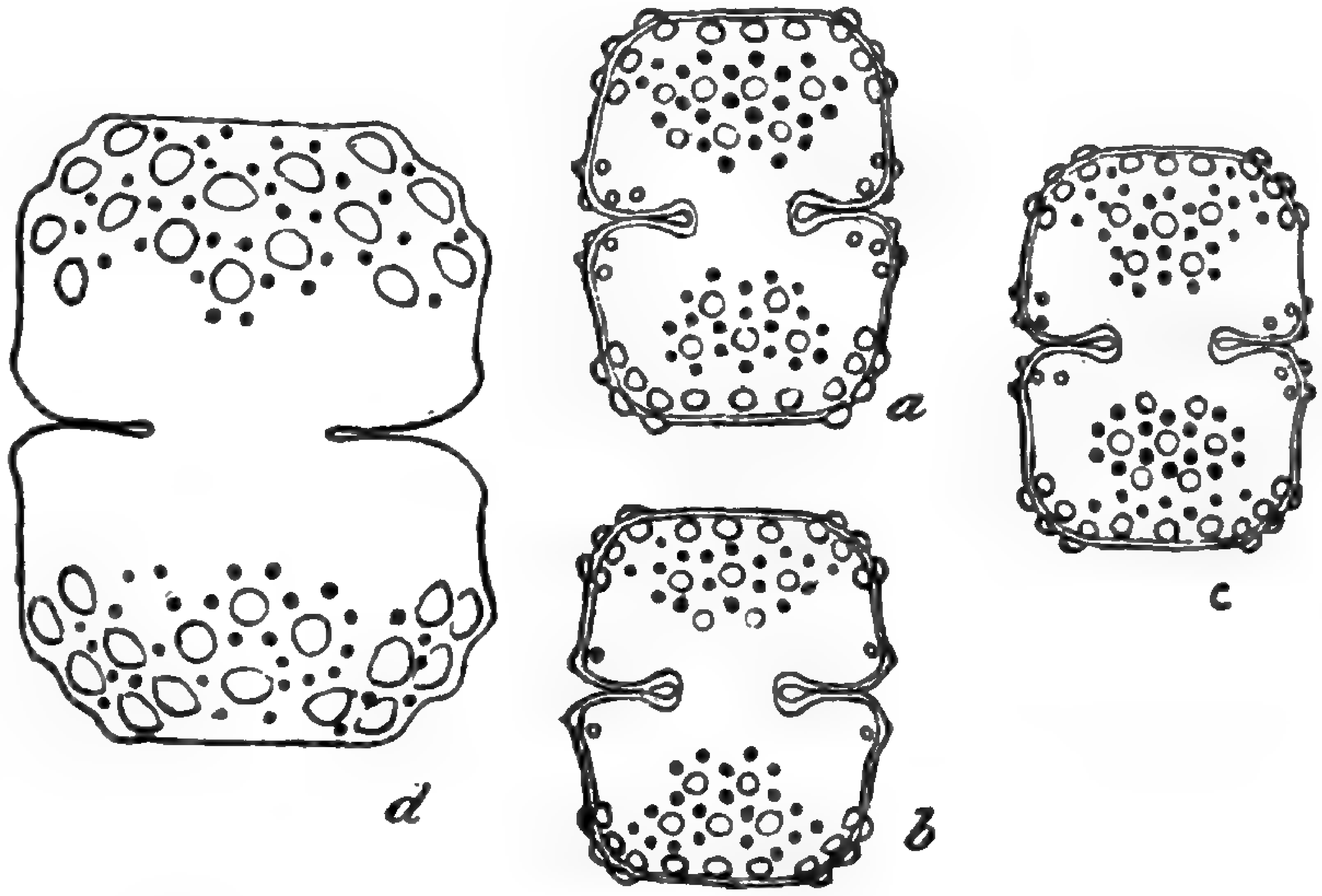

Fig. 5.—*Cosmarium triplicatum*, Wolle.
a & *b*. Specimens from Minneapolis, ×520. *c*. Specimen from Scarbro', Maine, ×520. *d*. Specimen from Sisson, California (after Johnson), ×770.

117. C. triplicatum, *Wolle*, 1883; *Desm. U. S.* p. 73, pl. 19. ff. 3–6.

Long. 44–52 μ; lat. 34·5–43 μ; lat. isthm. 10–14 μ; crass. 28 μ. (Fig. xylogr. 5.)

Hab. Bridgeport, Conn., common (H. J. no. 215). Ann Arbor, Mich. Orono and Scarbro', Maine. Minneapolis, Minnesota. Holderness (H. J. no. 375) and Plymouth, N.H. Burlington,

Kans. Seattle, Wash. Sisson, Calif. (H. J. no. 403). Tallahassee, Florida.

The description of this plant given by Wolle (*l. c.*) is very good so far as it goes, but he has entirely omitted to mention the surface markings situated slightly above the middle of the semicells. We have seen this species from many parts of the United States, and its characters are fairly constant; the semicells are subrectangular, with faintly retuse sides which gently converge towards the straight apex, the superior angles being more rounded than the inferior ones. The three large hemispherical granules at each superior angle, the three within each of these angles, and the three just within the apex are quite constant in all the specimens we have examined.

Across the upper part of the semicells there are from 5 to 7 large granules, more depressed than those at the superior angles and arranged in two or three transverse series, this arrangement being variable even on the two halves of the same cell. Surrounding these central granules are hexagons of rather conspicuous scrobiculations, the latter often extending among the marginal granules. The granules at the inferior angles are smaller than those on the other parts of the semicell; there are usually two on the margin and two or three within, but more rarely specimens are met with which possess only one on the margin and one within.

Fig. 5 *d* (which is from a drawing by Johnson) has a rather different arrangement of the surface granules, and the middle one of the three within the apex is situated rather below the other two.

118. Cosmarium subspeciosum, *Nordst. in Öfvers. K. Vet.-Akad. Förh.* 1875, no. 6, p. 22, t. 6. f. 13.

Long. 42 μ; lat. 32 μ; lat. isthm. 11 μ; crass. 21 μ.

Hab. Wake Forest, N.C. (H. J. no. 522).

This was recorded by Johnson (Bull. Torr. Bot. Club, xxii. 1895, no. 7, p. 293) as *C. costatum*, Nordst.; his drawing, however, is identical in all respects with typical forms of *C. subspeciosum*.

119. C. moniliforme, *Ralfs, Brit. Desm.* p. 107, t. 17. f. 6. —Tessarthonia moniliformis, *Turp.*

Forma panduriformis, *Heimerl, in Verh. d. k.k. zool.-bot. Ges. Wien,* 1891, p. 598, t. 5. f. 11.

Long. 25 μ; lat. 15 μ; lat. isthm. 9 μ. (Pl. **17**. fig. 15.)
Hab. Cold Spring Harbour, N.Y. (H. J. no. 237).

Forma ELONGATA. (Pl. **17**. fig. 14.)
Forma semicellulis longitudinaliter late ellipticis.
Long. 41 μ; lat. 11 μ; lat. isthm. 7 μ.
Hab. Laconia, N.H. (H. J. no. 658).

120. COSMARIUM VIRIDE, *Josh. in Journ. Bot.* xxiii. (1885), p. 34, pl. 254. f. 3.—Colpopelta viridis, *Corda*, 1834.
Long. 48–49 μ; lat. 25–26 μ; lat. isthm. 20 μ.
Hab. Staten I., N.Y. (H. J. no. 479). Ithaca, N.Y. (H. J. no. 490). Easton, Conn. Holderness, N.H.

121. C. THWAITESII, *Ralfs, Brit. Desm.* p. 109, t. 17. f. 8.
Lat. 40 μ.
Hab. Sisson, Calif. (Mt. Shosta, at 3500 feet). Palo Alto, Calif. (H. J. no. 500).

XV. COSMOCLADIUM, *Bréb.*

122. C. QUIMBYI, *Wood, in Smithson. Contrib. Knowl.* xix. (1874) no. 9, p. 134, t. 1. f. 9; *Wolle, Desm. U. S.* p. 61.
Lat. circ. 18 μ.
Hab. Staten I., N.Y.; abundant in Silver Lake, forming bright green gelatinous masses (H. J. nos. 383 & 384).

XVI. SPONDYLOSIUM, *Bréb.*

123. S. MONILIFORME, *Lund. in Nov. Act. Soc. Scient. Ups.* Ser. III. viii. no. 2, p. 92, t. 5. f. 16.
Long. cell. 34 μ; lat. 17 μ.
Hab. Laconia, N.H., occasional (H. J. no. 680).

124. S. PULCHRUM, *Arch. in Pritch. Infus.* ed. IV. p. 724.—Sphærozosma pulchrum, *Bail. in Ralfs, Brit. Desm.* p. 209, t. 35. f. 2.

Var. INFLATUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 231, pl. 12. f. 10.—Sphærozosma pulchrum var. inflatum, *Wolle*.
Lat. 60 μ.
Hab. Laconia, N.H., scarce (H. J. no. 667).

125. SPONDYLOSIUM RECTANGULARE, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 231, pl. 12. ff. 13, 14.—Sphærozosma rectangulare, *Wolle*; Sphærozosma Göbelii, *Racib.*

Long. 21–22 μ; lat. 60–68 μ; lat. isthm. 12·5–16 μ.

Hab. De Land, Florida (H. J. no. 582). Malaga, N.J.

The specimens from Florida possessed somewhat smaller teeth than those from New Jersey. A figure of the basal view of a semicell is given (Pl. **18**. fig. 4).

XVII. STAURASTRUM, *Meyen.*

126. S. SIBIRICUM, *Borge, in Bih. till K. Sv. Vet.-Akad. Handl.* xvii. (1891) no. 2, p. 9, t. 1. f. 4.

Forma TRIGONA, *West & G. S. West, in Journ. Roy. Micr. Soc.* 1896, p. 157, pl. 4. f. 39.

Long. 16·5 μ; lat. 16 μ; lat. isthm. 8·5 μ.

Hab. Minneapolis, Minnesota.

127. S. DIPTILUM, *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* 1869, nos. 14–15, p. 227, t. 4. f. 56.

Long. (s. spin.) 19 μ; lat. s. spin. 16·5 μ, c. spin. 29 μ; lat. isthm. 5 μ. (Pl. **18**. fig. 8.)

Hab. De Land, Florida.

128. S. TRIFIDUM, *Nordst. l. c.* p. 226, t. 4. f. 51.

Long. 32 μ; lat. 32 μ.

Hab. Seattle, Wash., occasional.

129. S. BRASILIENSE, *Nordst. l. c.* p. 227, t. 4. f 39.

Hab. De Land, Florida, frequent.

130. S. RAVENELII, *Wood, in Smithson. Contrib. Knowl.* xix. (1874) no. 9, p. 153, t. 21. f. 22.

Lat. 18–25 μ.

Hab. Northfield, Mich. (H. J. no. 165). Wake Forest, N.C. (H. J. no. 519).

131. S. ERASUM, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg*, iv. p. 143, t. 1. f. 28.

Forma ESPINULOSA, *Lund. in Nov. Act. Soc. Scient. Ups.* Ser. III. viii. no. 2, p. 62.

Lat. 32–37 μ.

Hab. Edgemoor, Ind. Whitmore Lake, Mich. (H. J. no. 449).

132. STAURASTRUM HEXACERUM, *Wittr. in Bih. till Vet.-Akad. Handl.* i. no. 1, 1872, p. 51.—Desmidium? hexaceros, *Ehrenb.*

Var. AVERSUM, n. var. (Pl. **18**. fig. 13.)

Var. semicellulis angulis productis et sursum curvatis; a vertice visis lateribus leviter concavis.

Long. 18 μ; lat. 20·5 μ; lat. isthm. 4·5 μ.

Hab. Bridgeport, Conn.

133. S. STRIOLATUM, *Arch. in Pritch. Infus.* ed. IV. p. 740.—Phycastrum striolatum, *Näg. Gatt. einz. Alg.* p. 126, t. 8 A. f. 3.

Forma BRASILIENSIS, *W. B. Turn. in K. Sv. Vet.-Akad. Handl.* xxv. no. 5, p. 109, t. 13. f. 15.

A form with the apex very slightly convex.

Long. 25 μ; lat. 22 μ; lat. isthm. 7 μ.

Hab. Laconia, N.H. (H. J. no. 676).

134. S. PUNCTULATUM, *Bréb. in Ralfs, Brit. Desm.* p. 133, t. 22. f. 1.

Hab. Ann Arbor, Mich., with zygospores (H. J. nos. 319 & 320). Abundant from many other States.

135. S. LACONIENSE, n. sp. (Pl. **18**. fig. 9.)

S. parvum, 1½-plo latius quam longum, profundissime constrictum, sinu angusto-lineari; semicellulæ elliptico-semicirculares, angulis lateralibus in processus breves bifurcatos productis, marginibus infra processus brevibus et convergentibus ad sinus cum denticulo singulo, dorso alto convexo cum verrucis emarginatis circ. 8, serie verrucarum emarginatarum vel truncatarum 8 intra dorsum, et verrucis duabus in centro; a vertice visæ subangustæ ellipticæ, polo unoquoque cum processu brevi bifurcato, lateribus verrucis 10 præditis, iis medianis binis majoribus utrobique; a latere visæ hexagono-circulares, marginibus lateralibus superioribus cum verrucis subtruncatis 3 instructis.

Long. 26 μ; lat. 39 μ; lat. isthm. 8·5 μ; crass. 17 μ.

Hab. Laconia, N.H. (H. J. no. 643).

The front view of this species has a slight resemblance to *S. forficulatum*, Lund.

136. S. COSMARIOIDES, *Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenh.* 1869, nos. 14–15, p. 223, t. 4. f. 43 (1870).

Long. 64 μ; lat. 36 μ; lat. isthm. 16 μ.

Hab. De Land, Florida.

137. STAURASTRUM PACHYRHYNCHUM, *Nordst. in Öfvers. K. Vet.-Akad. Förh.* 1875, no. 6, p. 32, t. 8. f. 34.

Long. 31–34·5 μ; lat. 31·5–35 μ; lat. isthm. 8–9·5 μ.

Hab. Harvey Lake, Pennsylvania. Minneapolis, Minnesota.

138. S. SUBLÆVISPINUM, n. sp. (Pl. 18. figs. 20–22.)

S. parvum, 1½-plo latius quam longum (cum processibus), profunde constrictum, sinu aperto et obtuso; semicellulæ corpore inconspicuo, processibus digitatis duobus late divergentibus, marginibus processuum parallelibus ad apices subito attenuatis; a vertice visæ triradiatæ, corpore inconspicuo; membrana glabra.

Long. 25 μ; lat. 37 μ; lat. isthm. 7 μ.

Hab. Laconia, N.H. (H. J. no. 651).

This species approaches *S. lævispinum*, Biss., but is relatively very much broader, has much less body, and has cylindrical processes only attenuated at their extremities.

139. S. PSEUDOTETRACERUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 79, pl. 8. f. 39.—S. contortum, *Delp.*, var. pseudotetracerum, *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 50, t. 5. f. 14.

Long. s. proc. 15–17 μ, c. proc. 24–27 μ; lat. c. proc. 21–22 μ lat. isthm. 5·5 μ.

Hab. Harvey Lake, Pennsylvania.

140. S. IRREGULARE, *West, in Journ. Roy. Micr. Soc.* 1894, p. 12, pl. 2. ff. 49, 50.

Long. s. proc. 9·5 μ, c. proc. 20 μ; lat. c. proc. 17–24 μ; lat. isthm. 5·5 μ; crass. 9 μ.

Hab. Harvey Lake, Pennsylvania. Whitmore Lake, Mich. (H. J. no. 451). De Land, Florida.

141. S. TENUISSIMUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*) v. p. 78, pl. 8. f. 43.

Long. s. proc. 11·5 μ, c. proc. 23 μ; lat. s. proc. 9 μ, c. proc. 29 μ; lat. isthm. 4 μ.

Hab. De Land, Florida.

142. S. IOTANUM, *Wolle*, 1884; *Desm. U. S.* p. 137, pl. 51. ff. 5–7.

The plants seen by Johnson and regarded by him as most

probably *S. iotanum*, are precisely similar to those we have noticed from England and the United States, and which we have always thought to be Wolle's species. As Wolle's description is too meagre and somewhat incorrect, and his figures very indistinct, we feel it desirable to describe and figure this species.

S. minutissimum et inconspicuum, paullo latius quam longum (cum processibus), modice constrictum, sinu parvo acutangulo aperto; semicellulæ subrectangulares, angulis basalibus subrectangularibus et non rotundatis, apicibus levissime convexis, angulis superioribus in processus longos divergentes bi- vel trinodulosos productis, apicibus processuum emarginatis; a vertice visæ triangulares, lateribus subrectis, angulis in processus longos nodulosos productis; membrana glabra.

Long. s. proc. 8–10 μ, c. proc. 13–20 μ; lat. s. proc. 6–9 μ, c. proc. 13–21 μ; lat. isthm. 3·5–4 μ. (Pl. **18.** figs. 14, 15.)

Hab. Bridgeport, Conn. (H. J. no. 527).

143. Staurastrum bicoronatum, *Johns. in Bull. Torr. Bot. Club*, xxi. (1894), p. 290, t. 211. f. 9.

Hab. Whitmore Lake, Mich. (H. J. no. 454). Malaga, New Jersey.

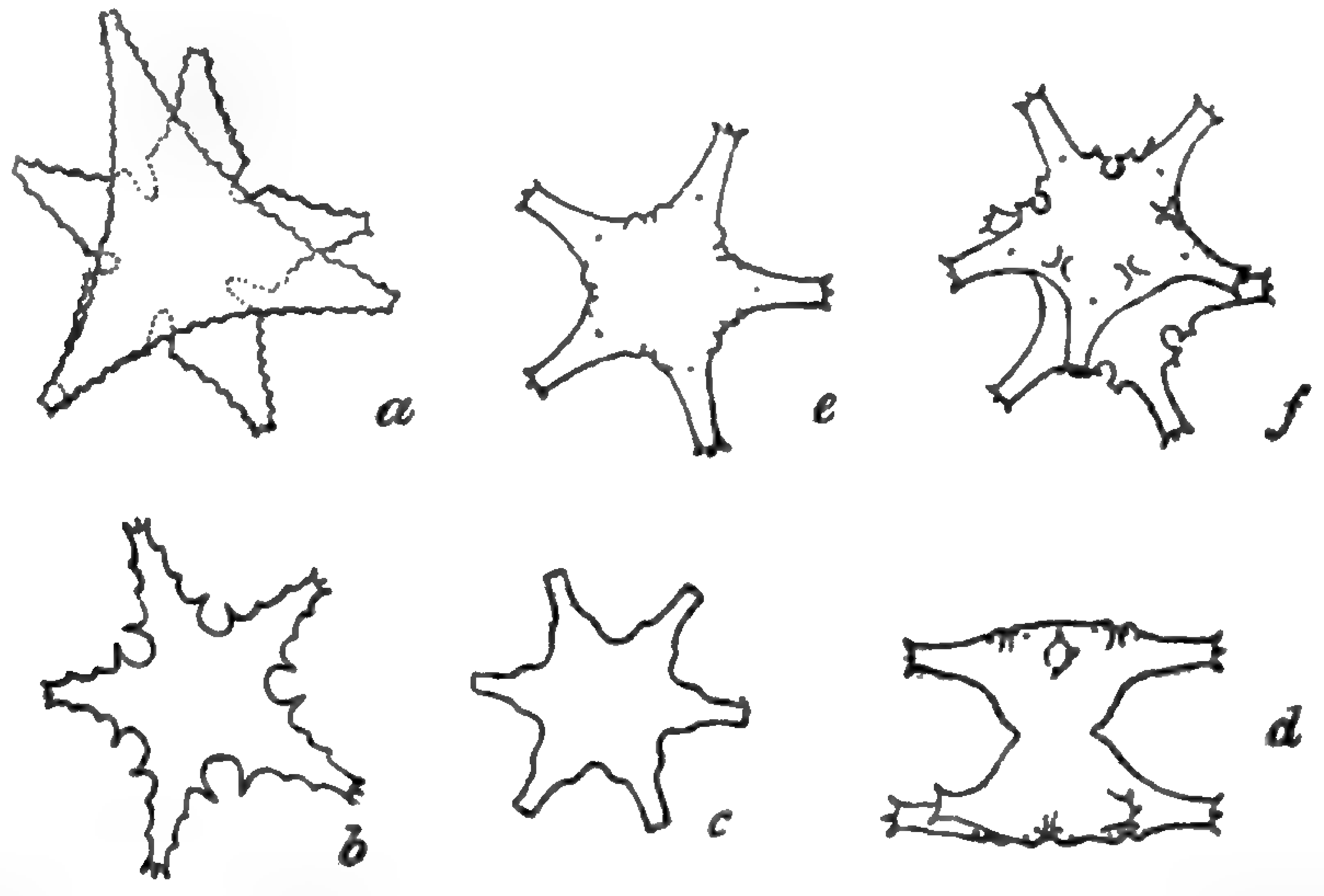

Fig. 6.—*a. S. incisum*, Wolle, abnormal form, × 600. *b.* Ditto, × 700. *c. S. pulchrum*, Wolle, ×400. *d, e, f. S. distentum*, Wolle, ×520. (*f* is somewhat oblique.)

144. S. incisum, *Wolle, Desm. U. S.* p. 132, pl. 41. ff. 12–14. A figure is given of a normal (fig. xylogr. 6 *b*) and an abnormal

(fig. xylogr. 6 *a*) form of this species for comparison with *S. distentum*.

Hab. Edgemoor, Ind. Bridgeport, Conn. (H. J. nos. 54 & 193). Ann Arbor, Mich. (H. J. no. 323).

145. STAURASTRUM DISTENTUM, *Wolle*, 1882; *Desm. U. S.* p. 149, pl. 41. ff. 15–16.

Long. 25 μ; lat. 38 μ; lat. isthm. 8·5 μ. (Fig. xylogr. 6 *d–f*.)

Hab. De Land, Florida. Harvey Lake, Pennsylvania, abundant.

This species, which we have seen in abundance, has a minute furcate spine, or rather a small emarginate wart, on each side of the incision between the processes; owing to their position these warts are best seen when the plant is oblique. This character is not mentioned by Wolle, although it is due to the presence of these emarginate warts that the apex in front view is "crenulate." In all the specimens we have examined the incision between the processes is a mere notch and not "a deep linear sinus," and, like the emarginate warts, is best seen when the plant is an oblique position.

In Johnson's specimens from Florida this incision was rather wider, otherwise they were identical with the Pennsylvania examples. In all cases the processes of one semicell alternate with those of the other.

A figure is given of a vertical view of *S. pulchrum*, Wolle, for comparison with this species (fig. xylogr. 6 *c*).

146. S. CORONULATUM, *Wolle, Desm. U. S.* p. 135, pl. 44. f. 11.

Lat. 84 μ.

Hab. De Land, Florida, scarce (H. J. no. 591).

"It seems doubtful whether this is distinct from a six-rayed *S. Ophiura*, Lund."

147. S. ARACHNE, *Ralfs*, 1845; *Brit. Desm.* p. 136, t. 23. f. 6.

Long. 25 μ; lat. 52 μ.

Hab. De Land, Florida.

American forms of this species very often have all the processes (as seen in vertical view) curved in the same direction (as in *S. cyrtocerum*).

148. STAURASTRUM VESTITUM, *Ralfs, Brit. Desm.* p. 143, t. 23. f. 1.

Var. TORTUM, n. var. (Pl. **18**. fig. 16.)

Var. semicellulis a vertice visis processibus curvatis (ut in *S. cyrtocero*) et tortis.

Lat. 65 μ.

Hab. Bridgeport, Conn.

The processes are not only curved but twisted on their axes, the dorsal verrucæ causing the outer curve of the processes to be very rough and the inner one almost smooth.

149. S. GRACILE, *Ralfs*, 1845; *Brit. Desm.* p. 136, t. 22. f. 12.

A figure is given (Pl. **18**. fig. 7) of an abnormal form from Whitmore Lake, Mich. (H. J. no. 456).

150. S. CONCINNUM, n. sp. (Pl. **18**. fig. 17.)—S. forficulatum, *Wolle, Desm. U. S.* p. 144, pl. 51. ff. 16–19 (*non Lundell*).

S. submagnum, $1\frac{1}{2}$-plo latius quam longum (cum processibus), modice constrictum, sinu aperto acutangulo; semicellulæ subtrapeziformes (vel obverse semicirculares), angulis in processus horizontales breves validos productis, marginibus processuum spinulosis, apicibus processuum cum spinis magnis divergentibus tribus, dorso leviter convexis cum processibus brevibus bifurcatis 6 ad marginem; a vertice visæ triangulares vel quadrangulares, angulis in processus breves productis, lateribus concavis cum processibus brevibus bifurcatis 6 ad marginem unumquemque.

Long. 44 μ; lat. 68 μ; lat. isthm. 14 μ.

Hab. Florida (H. J. no. 555).

This is evidently the same plant as the one Wolle named *S. forficulatum.* Johnson remarks that the short bifurcate processes are sometimes twice bifid. It seems to us to be nearer *S. vestitum*, Ralfs, than *S. forficulatum*, Lund.

151. S. ELONGATUM, *Barker, in Quart. Journ. Micr. Sc.* ix. p. 424.—S. terebrans, *Nordst.*

Long. 65 μ; lat. 36–42 μ; lat. isthm. 9 μ.

Hab. De Land, Florida; common.

152. S. LEPTOCLADUM, *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* 1869, nos. 14–15, p. 228, t. 4. f. 57. Inclus. var. *cornutum*, Wille, in Bih. till K. Sv. Vet.-Akad. Handl. viii. no. 18, t. 1. f. 39.

There can be no doubt that *S. leptocladum* always possesses the two spines at the apex of the semicells; this was made the character for a variety (v. *cornutum*) by Wille, but we think it highly probable that these spines had been broken off in the specimens originally described by Nordstedt. All the examples we have ever seen of this species from many diverse parts of the world possessed these spines, and it is worthy of note that other observers record only the v. *cornutum*, a fact which confirms our suspicions as to the invariable presence of the apical spines in uninjured examples.

153. Staurastrum Johnsonii, *West & G. S. West, in Trans. Linn. Soc.*, Ser. II. (*Bot.*), v. p. 266, pl. 17. f. 16.

Hab. Cold Spring Harbour, N.Y. (H. J. no. 176). Ann. Arbor, Mich. (H. J. n. 312). Meredith and Holderness, N.H. Whitmoor Lake, Mich. Laconia, N.H.

154. S. Anchora, *West & G. S. West, l. c.* pl. 17. ff. 18–20.

Long. 76 μ; lat. 140 μ.

Hab. Laconia, N.H. (H. J. no. 657).

155. S. Cerastes, *Lund. in Nov. Act. Soc. Scient. Ups.* Ser. III. viii. no. ii. p. 69, t. 4. f. 6.

Long. 56 μ; lat. 64 μ.

Hab. De Land, Florida (H. J. no. 589).

156. S. macrocerum, *Wolle*, 1880; *Desm. U. S.* p. 134, pl. 43. ff. 3–5.

Lat. c. proc. 150–165 μ.

Hab. De Land, Florida, occasional (H. J. no. 592).

157. S. radians, n. sp. (Pl. **18**. fig. 18.)

S. mediocre, pæne duplo latius quam longum (cum processibus), modice constrictum; semicellulæ obverse subsemicircularibus, apicibus subrectis glabrisque, angulis in processos validos horizontales productis, apicibus processuum tridentatis (ut visis); a vertice visæ circulares processibus validis radiantibus 8, verruca emarginata ad basin processus uniuscujusque utrobique et denticulis duobus ad marginem unumquemque, apicibus processuum quadridentatis; membrana glabra.

Long. 42 μ; lat. 68–80 μ; lat. isthm. 21 μ.

Hab. De Land, Florida (H. J. no. 583).

Var. EXTENSUM. (Pl. **18**. fig. 19.)

Var. processibus elongatis et tenuioribus, denticulis 4 vel 5 ad marginem unumquemque.

Lat. 81 μ.

Hab. De Land, Florida.

158. STAURASTRUM ARCTISCON, *Lund. in Nov. Act. Soc. Scient. Ups.* Ser. III. viii. no. ii. p. 70, t. 4. f. 8.—Xanthidium Arctiscon, *Ehrenb.*

Hab. Bridgeport, Conn. Cold Spring Harbour, N.Y. Meredith and Holderness, N.H. Burlington, Kansas, frequent in ponds with *Azolla.* Whitmore Lake, Mich.

159. S. LEPTACANTHUM, *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* 1869, p. 229, t. 4. f. 46.

The form of this species seen from Florida possessed nine radial processes and six apical processes, thus having the same proportion (4 : 6) of apical to basal processes as in the typical plant. Long. 48 μ; lat. 68 μ. (Pl. **18**. f. 12.)

160. S. KITCHELII, *Wolle,* 1882; *Desm. U. S.* p. 150, pl. 40. ff. 35, 36.

Long. c. proc. 57–64 μ; lat. c. proc. 57–67 μ. (Pl. **18**. figs. 10, 11.)

Hab. De Land, Florida (H. J. no. 599).

161. S. XIPHIDIOPHORUM, *Wolle,* 1885; *Alg. U. S.* p. 44, pl. 57. ff. 21, 22.

Var. BRACHYACANTHUM, *West & G. S. West, in Trans. Linn. Soc.* Ser. II. (*Bot.*), v. p. 269, pl. 18. f. 7.

Long. s. spin. 28 μ, c. spin. 48 μ; lat. 26 μ.

Hab. Seattle, Wash.

Probably the same as var. *simplex,* Wolle, but very different from his description and figure.

XVIII. ARTHRODESMUS, *Ehrenb.*

162. A. BIFIDUS, *Bréb. in Mém. Soc. Sci. Nat. Cherbourg,* iv. p. 135, t. 1. f. 19 μ.

Long. 11 μ; lat. 9 u; lat. isthm. 3 μ.

Hab. Seattle, Wash.

163. A. CONVERGENS, *Ehrenb.* 1838; *Ralfs, Brit. Desm.* p. 118, t. 20. f. 3.

Hab. Ann Arbor, Mich.; "a form quite abundant with the

spines parallel" (H. J. no. 309). De Land, Florida; "very strong spines, strongly recurved." Seattle, Wash.; "a rather slender form."

164. ARTHRODESMUS CURVATUS, *W. B. Turn. in K. Sv. Vet.-Akad. Handl.* xxv. no. 5, p. 135, t. 11. ff. 31, 33, t. 12. ff. 2, 7, 11, 13, et 15.

Forma cellulis late ellipticis; long. 64 μ; lat. s. spin. 46 μ; long. spin. 20 μ; lat. isthm. 9 μ.

Hab. De Land, Florida (H. J. no. 559).

165. A. INCUS, *Hass.* 1845; *Ralfs, Brit. Desm.* p. 118, t. 20. f. 4 *a–d.*

Var. VALIDUS, n. var. (Pl. **17**. fig. 16.)

Var. semicellulis obverse semicircularibus, apicibus subrectis, spinis longis validis divergentibus.

Long. s. spin. 35 μ, c. spin. 111 μ; lat. s. spin. 36 μ, c. spin. 76 μ; long. spin. 42 μ; crass. spin. ad bas. 3·5 μ; lat. isthm. 8·5 μ.

Hab. De Land, Florida.

These are the largest specimens of this species we have yet observed; in form they agree with one of the figures given by Wolle (Desm. U. S. pl. 24. fig. 3).

166. A. TRIANGULARIS, *Lagerh. in Öfvers. K. Vet.-Akad Förh.* 1885, no. 7, p. 244, t. 27. f. 22.

Var. INFLATUS, n. var.

Var. semicellulis latissime angulari-ellipticis, apicibus elevatis truncatisque, spinis validioribus et lævissime extrorsum curvatis.

Long. 38 μ; lat. s. spin. 21 μ, c. spin. 72 μ; lat. isthm. 7 μ.

Hab. Laconia, N.H. (H. J. no. 659).

XIX. SPHÆROZOSMA, *Corda.*

167. S. WALLICHII, *Jacobs. in Botan. Tidsskr.* viii. (1874), p. 211.—S. excavatum, var. β, *Wallich.*

Hab. Burlington, Kans. Seattle, Wash.

XX. DESMIDIUM, *Ag.*

168. D. APTOGONUM, *Bréb.* 1835.—Aptogonum Desmidium, *Ralfs, Brit. Desm.* p. 64, t. 32. f. 1.

Hab. Duval Co., Florida, abundant and conjugating (H. J. no. 295).

169. DESMIDIUM QUADRATUM, *Nordst. in Act. Univ. Lund.* ix. p. 49, t. 1. f. 24.

Hab. Baton Rouge, La., rare.

170. D. COARCTATUM, *Nordst. in Botan. Notiser,* 1887, p. 155; *in K. Sv. Vet.-Akad. Handl.* xxii. no. 8, p. 25, t. 2. f. 3.

Long. 29–33 μ; lat. 40–42 μ; lat. apic. 11·5–12·5 μ; lat. isthm. 31–32·5 μ; crass. 30 μ. (Fig. xylogr. 7.)

Hab. De Land, Florida.

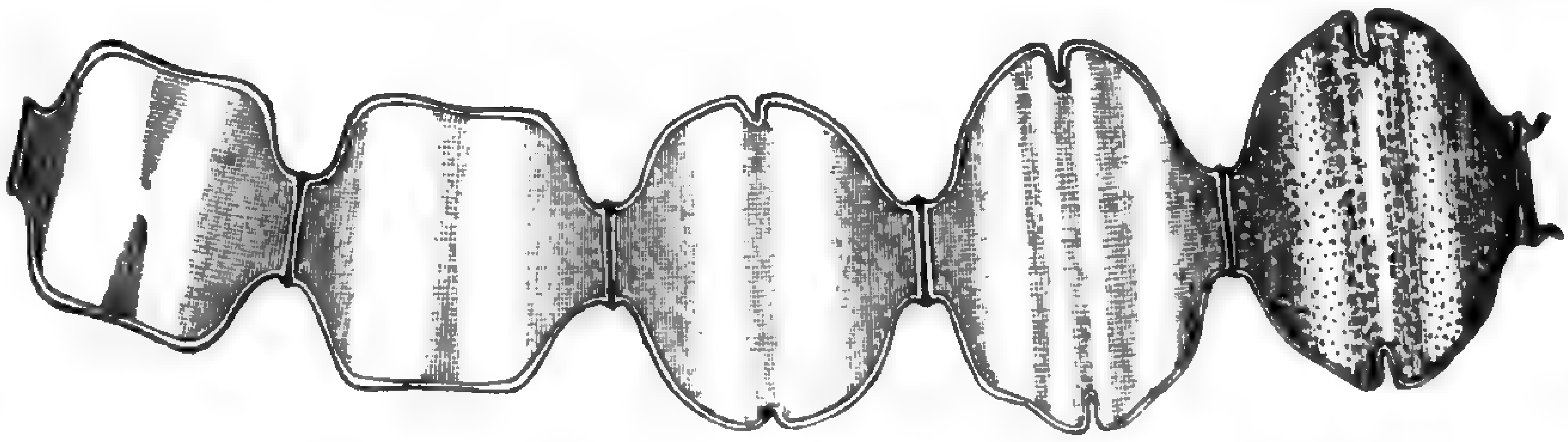

Fig. 7.—*Desmidium coarctatum,* Nordst. × 520.

The specimens were exactly like the New Zealand ones, but a little larger.

We fully agree with Dr. Nordstedt in considering *Leptozosma catenula,* W. B. Turn., as being the side view of *Desmidium graciliceps* or some allied form.

XXI. HYALOTHECA, *Ehrenb.*

171. H. NEGLECTA, *Racib. in Flora,* lxxxi. *Erg.* 1895, p. 30, t. 3. ff. 2, 3.

Long. 27–29 μ; lat. 12 μ.

Hab. De Land, Florida. Minneapolis, Minnesota. Malaga, New Jersey.

EXPLANATION OF THE PLATES.

a, a' = cellula vel semicellula a fronte visa.
b = „ „ vertice „
c = „ „ latere „
d = semicellula a basi visa.

PLATE 16.

Figs. 1, 2. *Closterium Johnsonii,* n. sp. 1, 175/1; 2, 525/1.
3, 4. „ *Toxon,* West, forma *elongata.* 3, 770/1; 4, 320/1.
5. *Micrasterias Johnsonii,* n. sp. 320/1.
6. „ *tetraptera,* n. sp. 560/1.

Fig. 7. *Euastrum subhexalobum*, n. sp. 750/1.
8. „ *intermedium*, Cleve, var. *validum*, n. var. 560/1.
9. „ *Johnsonii*, n. sp. 750/1.
10. „ *abruptum*, Nordst., forma *minor*. 520/1.
11. „ *evolutum*, West & G. S. West, var.
12. „ *doliforme*, n. sp. 520/1.
13. „ *oculatum*, Börg., forma. 520/1.
14. „ *pyramidatum*, West. 770/1.
15. *Cosmarium exiguum*, Arch., forma. 770/1.

PLATE 17.

Fig. 1. *Xanthidium Johnsonii*, n. sp. 1156/1.
2. „ *controversum*, n. sp. 525/1.
3. *Cosmarium capense*, De Toni, forma. 593/1.
4. „ *Johnsonii*, n. sp. 562/1.
5. „ *cosmetum*, West & G. S. West. 525/1.
6. „ *subnudiceps*, n. sp. 525/1.
7. „ *elegantissimum*, Lund., var. *simplicius*, n. var. 750/1.
8. „ *ordinatum*, West & G. S. West, var. *depressum*, n. var. 830/1.
9. „ *reniforme*, Arch. 562/1.
10. „ „ var. *compressum*, Nordst. 525/1.
11. „ „ var. *elevatum*, n. var. 562/1.
12. „ *modestum*, n. sp. 770/1.
13. „ *Rostafinskii*, Gutw., var. *americanum*, n. var. 750/1.
14. „ *moniliforme*, Ralfs, forma *elongata*. 562/1.
15. „ „ forma *panduriformis*, Heimerl. 770/1.
16. *Arthrodesmus Incus*, Hass., var. *validus*, n. var. 520/1.

PLATE 18.

Fig. 1. *Cosmarium pseudotaxichondrum*, Nordst., var. *floridense*, n. var. 520/1.
2, 3. „ *lunatum*, Wolle, var. *depressum*, n. var. 750/1.
4. *Spondylosium rectangulare*, West & G. S. West. 520/1.
5, 6. *Cylindrocystis americana*, n. sp. 562/1.
7. *Staurastrum gracile*, Ralfs, abnormal form. 770/1.
8. „ *diptilum*, Nordst. 520/1.
9. „ *laconiense*, n. sp. 525/1.
10, 11. „ *Kitchelii*, Wolle. 10, 520/1; 11, 750/1.
12. „ *leptacanthum*, Nordst. 560/1.
13. „ *hexacerum*, Wittr., var. *aversum*, n. var. 770/1.
14, 15. „ *iotanum*, Wolle. 14, 750/1; 15, from an English example, 520/1.
16. „ *vestitum*, Ralfs, var. *tortum*, n. var. 562/1.
17. „ *concinnum*, n. sp. 560/1.
18. „ *radians*, n. sp. 560/1.
19. „ „ var. *extensum*. 560/1.
20–22. „ *sublævispinum*, n. sp. 400/1.

DESMIDS FROM THE UNITED STATES

DESMIDS FROM THE UNITED STATES

G. S. West del.
H. Helick lith.

West Newman imp.

DESMIDS FROM THE UNITED STATES

NOTICE.

Vol. XXVI. is still in course of issue, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–219. (Complete.)

Vol. XXXII., Nos. 220–227. (Complete.)

Vol. XXXIII., Nos. 228, 229, 230, and 231 (the present Part).

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NOTICE.

The LIBRARY will be closed for cleaning during the month of AUGUST.

On Characeæ collected by Mr. T. B. Blow, F.L.S., in the West Indies. By Henry Groves, F.L.S., and James Groves, F.L.S.

(Plate 19.)

[Read 16th December, 1897.]

In the winter of 1894–5 Mr. Blow visited British Guiana and some of the southern West Indian Islands, and took every opportunity of searching for Characeæ. He examined many of the canals and swamps of Demerara, and went up the Essequibo River as far as the Gold Diggings, but failed to find any Characeæ. He was also unsuccessful in the islands of Grenada, St. Lucia, Martinique, Montserrat, and St. Kitt's, the only islands in which he was able to collect any being Antigua and Trinidad. So little is known of the *Chara* flora of the smaller West Indian Islands that it seems desirable to place these few notes on record, especially as one of the plants appears to us sufficiently distinct to rank as a species.

1. Chara zeylanica, *Willd.*, var. inconstans.—C. inconstans, *Kuetz. Tab. Phyc.* vol. vii. (1857) p. 28, t. 70. fig. 2.—C. gymnopus, var. inconstans, *Braun*, *Fragm. Mon. Char.* (1882) p. 193.

In a clay pond, San Fernando, Trinidad, 2nd January, 1895.

This seems to be exactly the plant referred to by Braun as having been collected by Crueger in the same island. It is characterized by the lowest segment of the branchlets being as long, or almost as long, as the second, and the corticate segments being 0–3 only.

C. zeylanica is a widely distributed and extremely variable species, occurring in Asia, Africa, North and South America, and Australia, and it is one of the commonest species in the tropics. Most botanists have followed Braun in adopting the name of *C. gymnopus*, Braun, but this name is clearly untenable. *C. zeylanica* was described and figured by Willdenow (Mém. Acad. Sci. Berl. 1803, p. 86, t. 2) in 1805, and there has never been any doubt as to the identity of the species referred to. *C. foliolosa*, a North-American form of the same species, was described at the same time. These names were followed by *C. compressa*, Kunth

(1815), *C. indica*, Bertero (1829), *C. verticillata*, Roxb. (1833), *C. armata*, Meyen (1835), and *C. haitensis*, Turpin, all of which Braun has referred to the same species. In 1835, Braun (in Regensb. Bot. Zeit. i. p. 70) described *C. polyphylla* (from Ohio) and *C. Commersonii* (from Bourbon) as new species. In 1844 (in Amer. Journ. Sci. vol. xlvi. p. 93) he classed *C. foliolosa* with *C. zeylanica* and *C. Michauxii* (his former *C. polyphylla*) "as subspecies under the principal species *C. polyphylla*, A. Braun." In 1845 (Boston Journ. Nat. Hist. v. 5) he distinguished seven subspecies of *C. polyphylla*, viz., *Michauxii*, *guadeloupensis*, *ceylonica*, *javanica*, *Muhlenbergii*, *Humboldtiana*, and *armata*. In 1847, in a note at the end of his account of the Swiss Characeæ, he mentioned the group of species with the ecorticate lowest segment of the branchlets as containing *C. gymnopus*, Braun, *C. Commersonii*, *C. armata*, *C. zeylanica*, *C. polyphylla*, *C. sejuncta*, and *C. Martiana*. This was, so far as we know, the first publication of the name *C. gymnopus*, and although there is no description, it seems quite clear that it was intended to refer only to the form from Egypt (the locality mentioned) as distinguished from the previously-described plants from other parts of the world. In 1858 (in Charac. aus Columb. Guyana u. Mittelamerika), he referred to *C. gymnopus* as the Egyptian plant, and in 'Characeen Afrika's' (1867) he first used the name in an aggregate sense. There is no doubt that Braun was the first to understand the extent of the species, but this does not in any way justify his selecting for it one of the most recent of his own segregate names.

2. C. ZEYLANICA, *Willd.*

In the hard clay bottom of a shallow ditch, Antigua, 18th January, 1895. A young sterile state from 1 to 2 in. high, with only the first and last segments ecorticate, and with small spine-cells.

3. NITELLA DICTYOSPERMA, sp. nov. (Sect. Diarthrodactylæ, homœophyllæ, flabellatæ, gymnocarpæ, monoicæ.)

Habitus proxime *N. oligospiræ*. Ramuli verticillorum fertilium circiter 6, similes, 2–3plo-furcati; radii primarii plerumque 5–6, radii secundarii 3–4, quorum 1–2 in radiis plerumque denuo trifurcati. Segmenta primaria ramulorum omnium

H. Groves del.
R. Morgan lith.

West, Newman imp.

NITELLA DICTYOSPERMA, *H. & J. Groves.*

longitudinem dimidiam proxime æquantia; segmenta ultima bicellularia, longitudine admodum inæqualia, cellulæ superiores acutæ ·09–·14 mm. longæ, ad basin ·027–·036 mm. latæ. Fructus solitarius ovoideus, sed paulo complanatus, ·44 mm. longus, ·31 mm. latus, in divisione ramulorum secundâ et nonnunquam tertiâ (rarius primâ) siti. Oospora ·28 mm. longa, crassitudine maximâ ·23–·24 mm., minimâ ·18 mm., 6-striata, liris prominentibus, membranâ fortiter reticulatâ. Coronula minuta. Antheridia in divisione ramulorum secundâ et nonnunquam tertiâ sita, diametro ·27–·30 mm.—(Plate **19**.)

Antigua, about half a mile from the Port, near the hospital, 18th January, 1895.

This species is nearest allied to *N. oligospira*, Braun, but it never has the ultimate rays regularly shortened as in the *Polyglochin* group, having only occasionally one shortened as in some of the *Mucronatæ*. In 'Hedwigia,' 1888, p. 94, Dr. Nordstedt refers to a form of *N. oligospira* from Porto Rico, in which the shortened segment is rare, and this may possibly belong to our species, but we have not seen specimens.

4. Nitella acuminata, *Braun*, var. subglomerata, *Braun*.

In a clay ditch, Perseverance Estate, Cedros, Trinidad, January 1895.

N. acuminata is a very widely-distributed species, occurring also in North Africa, the Western African Isles, Southern Asia, Japan, in the United States (principally in the southern part), in Mexico, British Guiana and Brazil. The var. *subglomerata* has its headquarters in Tropical America, but reaches as far north as New York.

5. N. cernua, *Braun*.

In the hard clay bottom of a shallow ditch, Antigua (with no. 2), 18th January, 1895.

A young state from 4 to 6 inches high, producing but two or three whorls, but with small fruiting branches. This species was first found by Gollmer at Caracas in Venezuela, and has since been recorded from Porto Rico (*Sintenis*) and Fernando de Noronha (*H. N. Ridley*, 1887).

EXPLANATION OF PLATE 19.

Fig. 1. *Nitella dictyosperma*, H. & J. Groves. Natural size.
2. " " Branchlet of young fruiting whorl. Magnified.
3. " " Fruiting node of do. × 30.
4. " " Plates of antheridium. × 60.
5. " " Young fruit. × 140.
6. " " Coronula. × 140.
7. " " Nearly ripe fruit. × 60.
8. " " Oospore, front view. × 60.
9. " " The same, side view. × 60.
10. " " Surface of oospore. × 425. From a photomicrograph kindly taken for us by Mr. J. Guardia.
11. " " Apices of ultimate rays, young. × 60.
12. " " The same, older. × 60.

A Revision of the genus ARENARIA, Linn.

By FREDERIC N. WILLIAMS, F.L.S.

[Read 17th February, 1898.]

I. INTRODUCTION.

THE first reference to *Arenaria* as the name of a genus is by Jean Bauhin *, who refers to it a plant sent to him by Sprenger from the neighbourhood of Ulm in Würtemberg; but the plant therein figured, and afterwards more fully described under the name of 'Arenaria : Holostei forte genus' by Dominique Chabrey†, is the species now known as *Sagina nodosa*, Fenzl.

The genus *Arenaria* was defined and circumscribed by Linnæus ‡ in the following terms :—

"*Calyx.* Perianthium 5-phyllum : foliolis oblongis, acuminatis, persistentibus.

Corolla. Petala 5, ovata, calyce ferme breviora, marcescentia.

Stamina. Filamenta 10, subulata, alterna interiora. Antheræ subrotundæ.

* 'Historia Plantarum Universalis,' iii. p. 723 (1651).

† 'Omnium Stirpium Sciagraphia et Icones,' p. 450 (1677).

‡ 'Genera Plantarum,' ed. I. p. 133, n. 374 (1737).

Pistillum. Germen ovatum. Styli 3, erecto-reflexi. Stigmata crassiuscula.

Pericarpium. Capsula ovata, tecta, unilocularis, apice 5-fariam dehiscens.

Semina. Plurima, reniformia."

Linnæus enumerated 25 species, of which 11 occur in the first edition of 'Species Plantarum.' The genus *Arenaria* even when thus circumscribed includes a number of species which can only be grouped by an association of characters, and cannot be marked off from allied genera by any single character taken separately. As Godron long ago pointed out, if *Lychnis* is to be considered as a genus distinct from *Silene*, then *Alsine* should be considered as distinct from *Arenaria*; since in each case a primary differential character is the number of the teeth of the capsule in relation to the number of the styles. The presence of a strophiole at the hilum of the seed is a constant character, and important enough to exclude a number of species included by some authors in *Mœhringia*; though this differential character is not mentioned in the Linnean diagnosis of the genus. In his recent Revision of the tribe *Naucleeæ*, Mr. G. D. Haviland * says: "that a natural classification is one in which the characters chosen in each group are those most convenient for the group, the groups having been formed by noticing similarity in very many characters rather than in one or two of supposed importance. Whilst on this view a perfect classification is impossible, the object of classification is most easily defeated by the introduction of a number of different classifications, and most easily attained by using only one." With this view of the handling of available characters I most cordially agree, and it is the only method of dealing with groups of species in genera such as those of which Boissier says,—"characteres ipsius generis non sat liquidi sunt, etiam characteres ad sectiones definiendas vel deficiunt vel non sat firmi sunt." In such genera it is well to take specimens of a few well-marked and distinctive species, examine them critically, and note down in full detail their characters; taking care to select in the genus such species as are most diverse one from another. If around these distinctive species are grouped others in the genus which are most like them respectively, an objective classification results which is far better and

* Journ. Linn. Soc., Bot. xxxiii. p. 1 (1897).

more workable than one based on a combination of theoretic characters, which would either fail to include some species, or result in the overlapping of groups.

Most of the other proposed genera frequently included under *Arenaria*, in its comprehensive sense, are best considered as primary subdivisions of *Alsine*. The genus *Arenaria*, in this paper, is defined more in accordance with Fenzl's circumscription of the admitted species, and as propounded by him in Endlicher's 'Genera Plantarum.'

It is difficult, in the species of a genus like *Arenaria*, to select constant characters which may seem to define satisfactorily and in a natural manner the primary subdivisions of the genus. After examination of a large number of specimens, both in the herbarium and in the living state, I have decided to base the primary subdivisions of the genus on the association of two characters which seem fairly constant, viz., the structure of the disk, and the number of teeth formed by dehiscence of the ripe capsule. This latter character is generally dependent on and associated with a definite number of styles, but not invariably. For, though one of the important generic characters is that the capsular teeth are twice the number of the styles, it is found that the number of styles sometimes varies in specimens of the same species, or even in flowers of the same specimen, while the capsular teeth are not so liable to casual variation. In such cases, the furrows on the surface of the ovary, which are present in many species, and which correspond with the usual number of styles, are a more trustworthy character, though these furrows usually disappear with the distention of the ovary after fertilization. The structure of the disk is a character which few botanists besides Edmond Boissier have noticed in their descriptions of species, and the verification of this character has entailed a considerable examination of material. Plants belonging to *Arenaria* are of little horticultural interest, and it is difficult to obtain for examination an extensive series of living or fresh specimens. Several species grown and cultivated in the Herbaceous Ground at Kew, which have flowered in the course of the past few seasons, have afforded advantages for examining specimens of different groups side by side under favourable conditions. After carefully studying the delimitation of other genera of Caryophyllaceæ formed on the basis of analogous fruit-characters, and their association into groups, and taking into account

geographical distribution and systematic variation as shown in the large or small number of species circumscribed by the more important generic types, I propose to define the limits and scope of the genus more in accordance with the views expressed by Fenzl, rather than with those of botanists with a more synthetic bias.

No systematic account of the known species of *Arenaria* has hitherto been given. A conspectus of sections, preceded by a short historical introduction, was published in November 1895 as a preliminary instalment* of a detailed examination of the species. The undiscriminating list of the species by Persoon †, and the fragmentary and meagre descriptions of those enumerated by Seringe ‡, throw but little light on the affinities of the groups of species; and it is only the painstaking and critical investigations of Fenzl that have advanced in any way our knowledge of this widely-distributed genus. Some objection may be raised to the sinking of *Dolophragma*, Fenzl, and *Brachystemma*, Don, in *Arenaria*: but the limitation of genera, in natural groups like the order Caryophyllaceæ, requires a coordination of primary with secondary characters in an uniform manner in subordinate groups of genera, in order to preclude, as far as possible, the isolation of individual genera distributed sporadically in the guise of what are called (in some German systematic works) "Mittelgattungen"; and such that the connecting links in allied groups of genera should be in a radiating and peripheral series, rather than in a linear and dichotomous series. In a large natural order there are always a number of cycles of affinity which suggest groupings of genera, and the more uniform in coincidence their limitation the less excuse there will be for the definition of aberrant types.

The matter under the head of each species is arranged as follows. The name of the species is followed by the authority for the name and the work or memoir in which it was first published; the second reference is to a general work or important flora, in which several species of the genus are enumerated or described, such as the first volume of Boissier's 'Flora Orientalis,' or the third volume of Willkomm and Lange's 'Prodromus Floræ Hispanicæ.' Those species which were described before 1848

* Bull. Herb. Boiss. iii. p. 593.

† Syn. Plant. i. p. 502 (1805).

‡ DC. Prodr. i. p. 401 (1824).

are only mentioned by name in their place and are not described in the enumeration. In a few instances, however, where the original description is false, altogether misleading, or erroneous, and has been so copied into floras without correction, the species is described anew. By this exclusion of the description of species which have been long known, and which are therefore to be found in one or more general floras, the bulk of a systematic paper on a large genus is reduced. The species described are those of the last 50 years. After the citation or description, as the case may be, a few differential characters are given the more readily to distinguish the species from others in the same group, more particularly in subsidiary groups which include several species. Then are sometimes added a few critical or explanatory notes on the species and its varieties, where they may seem to be required. The geographical limits of the species are given, but not the full geographical distribution of each species, which would without advantage add considerably to the matter under the heading of each species; though for the less common ones the habitat is given in the usual way. The last item under each species is the iconography and synonymy. The iconography, verified by comparison with authentic specimens, is as full as possible, every plate with which I am acquainted being cited, excepting only those which are obviously bad or misleading. In every case the date of publication is added to the reference cited for the species: not, however, that priority of date in the currency of names is of so much importance as compared with the convenience of retaining long-established names, but for ready reference. The synonymy of *Alsine*, in so far as it does not concern *Arenaria* in its restricted sense, is not dealt with.

A few words of explanation as to the subdivision into subgenera may be necessary. Two-thirds of the number of the species, viz. 111, belong to the typical subgenus *Euarenaria*, which includes species in which disk-glands are not evident or are quite inconspicuous, and the capsule splits by six teeth or valves. In the subgenus *Eremogoneastrum* the disk is lobed, and the ten glands alternate with the stamens; all the species are narrow-leaved, with the basal leaves usually long and grass-like. In the subgenus *Pentadenaria* (so called in allusion to the five glands) the disk is expanded into five prominent glands, each bearing a stamen, so that the ten stamens are distinctly grouped in two series. The species of the subgenus *Dicranilla* are all

South American, and are collectively distinguished from all others in the genus by their habit. The leaves are densely crowded in an imbricate series on the short stems terminated by small solitary flowers; and the seeds are quite smooth, shining and black. In the small group of *Arenariastrum*, the capsule splits by four teeth which deepen into valves, containing few seeds. The species of the distinctive subgenus *Odontostemma* have petals eroded or laciniate at the margin, and are also characterized by the structure of the root. The last subgenus is founded on a species from the province of Yunnan described by Mr. A. Franchet*, which is remarkable for its long exserted styles and its distinctly lobed disk, which is half-free, with a somewhat concave receptacle truncate at the base.

In this Revision of the genus 168 species are admitted, under which are also grouped 103 varieties. Of these 168 species, 69 are represented in the iconography of the genus, and additional plates are also cited for 17 varieties. Not many more than a third, therefore, of the species have been figured.

II. Geographical Distribution.

Arenaria is a genus which includes plants of wide distribution both as regards latitude and altitude, chiefly confined to the north temperate zone; within the Arctic Circle extending beyond the limits of permanent human habitations, and in the Tropics found only at considerable elevations in mountainous districts. In the Old World species occur only in the northern hemisphere†, and the range of the genus is from the west coast of Spitzbergen, lat. 78° (*A. ciliata*), to the island of Socotra, lat. 13° (*A. serpyllifolia*), and from the island of Novaya Zemlya (*A. ciliata*) to the Nilghiri Mountains in Malabar, lat. 11° (*A. nilghirensis*). In the Himalayas species are found at considerable altitudes. In Capt. Deasy's recent expedition to North-western Tibet (1896–97), specimens of *A. polytrichoides* were gathered at 5800 metres. Many years ago specimens of the same species were collected by Sir J. D. Hooker in Tibetan Sikkim at 4800 metres, and specimens of *A. pulvinata* at 5400 metres, and specimens of *A. oreophila* at nearly as great an elevation in the same region. *A. densissima* was gathered in the Yak Pass by Mr. C. B. Clarke

* Bull. Soc. Bot. France, xxxiii. p. 432 (1886).

† The South-African *A. glandulosa* of Jacquin belongs to *Spergularia*.

at 5100 metres. Strachey and Winterbottom collected *A. festucoides* in Western Tibet at 4700 metres. In Tibetan Sikkim Sir J. D. Hooker also gathered specimens of *A. debilis* at 4750 metres. In the mountainous region of the province of Yunnan, J. M. Delavay found *A. longistyla* and *A. Delavayi* at 4000 metres. In the New World there are several species in North America, and a few extend as far south as Chile and Argentina. Specimens of *A. lanuginosa*, which have remained unnamed in Herb. Kew., were collected on the river Vera Cruz in Patagonia by Charles Darwin in the course of the voyage of the 'Beagle.' The genus is not represented in Australia. Several American species have been inadequately described, whose identification from dried specimens which have lain long in herbaria is unsatisfactory; but some of them from their habit and appearance might more than doubtfully be referred to *Alsine, Stellaria,* and probably also *Colobanthus.*

It may be noted that the spelling of geographical names of the localities cited is in the majority of cases that used in the 'Times' Atlas, which is most convenient for the purpose; but for Russian and Chinese names in which the Atlas is deficient, the lists issued by the Russian Imperial Geographical Society have been consulted and followed.

III. Synoptic Key.

ARENARIA

Linn., Gen. Plant. ed. I. (1737), p. 133, n. 374; ed. II. (1742), n. 446; *Syst. Nat.* ed. VI. (1748), n. 446; *Sp. Plant.* ed. I. (1753), p. 423; *Gen. Plant.* ed. V. (1754), n. 505; ed. VI. (1764), n. 569; ex emend. *Fenzl* in *Endl. Gen. Plant.* p. 967, n. 5234; etiam *Ledeb., Fl. Rossica,* i. p. 360; *Engl. et Prantl, Natürl. Pflanzenf.* iii. pt. 1 *b*, p. 84 (1889): characteribus autem a prioribus auctoribus definitis hoc in conspectu paullo mutatis.

Calyx 5-sepalus; sepala 5, imâ basi connata. Petala 5, integra, apice rotundata obtusa retusa vel emarginata, rarius erosa vel laciniata; interdum nulla. Stamina 10, rarius 5. Discus perigynus, staminifer; nunc annularis, glandulis inconspicuis vel obsoletis in discum immersis, nunc 5- vel 10-lobatus in glandulas prominentes expansus; hinc inde glandulæ aut 5 staminiferæ aut 10 inter stamina sitæ rarius staminiferæ, membranaceæ vel carnosæ, rotundatæ vel bigibbosæ. Gynæcium

meiomerum. Ovarium uniloculare ; styli 3 vel 2 (interdum in nonnullis floribus 4–5), a basi distincti. Capsula globosa ovoidea breviter oblonga vel rarissime cylindrico-conica, interdum depressa, primùm dentibus duplo stylorum numero dehiscens, demùm sæpius in valvas 3 vel 2 bidentatas interdum longitudinaliter fissas secedens. Semina estrophiolata nuda, reniformi-globosa vel a latere compressa, undique tuberculata scabra lævia vel lævissime nitida.

Herbæ annuæ biennes vel perennes, vel rarius suffruticosæ, sæpius cæspitosæ; nunc graciles vel rigidæ foliis subulatis parvisve, nunc diffusæ vel cæspitosæ foliis latioribus. Inflorescentia vulgo dichasiiformis ; flores nunc terminales, cymoso-paniculati thyrsoidei capitati vel solitarii, nunc rarius axillares subsolitarii. Petala alba, rarius rubella.

SYN. *Alsinanthus,* Desvaux, Journ. Bot. 1814 (nomen).
Alsinella, S. F. Gray, Nat. Arr. Brit. Pl. ii. p. 655 (1821).
Bigelowia, Rafin. in Journ. Phys. lxxxix. (1819), p. 289.
Brachystemma, D. Don, Prodr. Fl. Nepal. p. 216 (1825).
Brewerina, A. Gray, in Proc. Amer. Acad. viii. (1872), p. 620.
Dolophragma, Fenzl, in Ann. Wien. Mus. i. (1836), p. 63, t. 7.
Dufourea, Gren., in Act. Soc. Linn. Bord. ix. (1837), p. 25.
Eremogone, Fenzl, Verbr. Alsin. p. 13, t. ad p. 18 (1833).
Euthalia, Rupr., Fl. Caucasi, p. 220 (1869).
Gouffeia, Robill. et Cast., in DC. Fl. Franç. v. p. 609 (1815).
Leptophyllum, Ehrh., Beitr. iv. p. 147 (1789).
Lepyrodiclis, Fenzl, in Endl. Gen. Plant. p. 966 (1840).
Odontostemma, Benth. *ex* G. Don, Gen. Syst. Bot. i. p. 449 (1831).
Pettera, Reichb., Ic. Fl. Germ. Helv. v. p. 33, t. 220 (1841).
Plinthine, Reichb., Handb. Nat. Pfl. p. 298 (1837).

Subgen. 1. **Euarenaria.**—Sepala herbacea, vel basi indurascentia, vel interdum omnino coriacea ; apicibus recta vel recurva, rarius incurva. Petala integra, apice rotundata retusa vel raro emarginata. Stamina 10 (in paucis speciebus 5). Glandulæ obsoletæ vel inconspicuæ, in discum annularem immersæ. Ovarium trisulcatum multiovulatum; styli 3 (in nonnullis floribus interdum 4 vel 5). Capsula oligo- vel polysperma, 6 dentibus vel 6 valvis, vel sæpe 3 valvis bidentatis, dehiscens. Semina granulato-tuberculata lævia nitida vel rarius rugulosa.—Herbæ annuæ biennes vel perennes, vel rarius suffruticosæ ; in perennibus sæpius cæspitosæ.

Subgen. 2. **Eremogoneastrum.**—Sepala herbacea vel basi indurata; apicibus recta vel recurva. Petala integra, apice rotundata obtusa vel raro retusa. Stamina 10, glandulis alternantia. Discus crenato-lobatus, glandulis prominentibus. Ovarium trisulcatum multiovulatum. Styli 3 (in nonnullis floribus interdum 4). Capsula oligo- vel polysperma, ultra medium 6 valvis dehiscens. Semina tuberculata vel lævia.—Herbæ perennes, sæpius cæspitosæ, Asiaticæ et Americanæ; foliis angustis.

Subgen. 3. **Pentadenaria.**—Sepala interdum coriacea; apicibus recta vel recurva. Petala integra, apice obtusa retusa vel rarius denticulata. Stamina 10. Discus lobatus, in 5 glandulas staminiferas prominentes integerrimas vel emarginato-bigibbosas expansus. Styli 3. Capsula 6 dentibus vel 3 valvis bidentatis dehiscens. Semina granulato-tuberculata vel lævissima.—Species perennes, sæpe suffruticosæ.

Subgen. 4. **Dicranilla.**—Sepala apicibus marginibusque inflexis conniventia. Petala integra, in aliquot speciebus nulla. Stamina 5 vel 10, glandulis suffulta. Ovarium trisulcatum; styli 3 (interdum 2). Capsula membranacea ovoidea oligosperma, ultra medium 6 valvis dehiscens. Semina lævissima nitida nigra.—Herbæ alpicolæ, meridionali-Americanæ, pulvinatim cæspitosæ, habitû ab iis aliorum subgenerum valde diversæ. Folia confertissime 4–5-fariam imbricata minuta ovata vel ovato-lanceolata carinata. Flores terminales solitarii sessiles minimi, foliis occultati; gemmæ axillares, increscentes tandem alares.

Subgen. 5. **Arenariastrum.**—Sepala herbacea vel rarius subscariosa, angusta; apicibus in anthesi erecta conniventia nunquam inflexa. Stamina 10, rarius 5 ananthera. Glandulæ obsoletæ vel inconspicuæ, in discum annularem immersæ. Styli 2. Capsula oligosperma, primum 4 dentibus conniventibus dehiscens, tandem in valvas secedens. Semina scabra vel granulato-tuberculata, subglobosa.—Herbæ annuæ vel biennes multifloræ, sæpius diffusæ.

Subgen. 6. **Odontostemma.**—Sepala anguste hyalino-marginata. Petala erosa vel laciniata. Stamina 10, paullo supra basin utroque latere gibbosa (veluti glandulâ bigibbosâ insidentia). Ovarium multiovulatum; styli 2. Capsula (ovulorum abortu) oligosperma, 4 valvis dehiscens. Semina magna compressa,

granulato-tuberculata vix lævia.—Species perennes sæpius valde glandulosæ et pilosæ, omnes Himalaïcæ vel Yunnanenses: radix (saltem in pluribus speciebus) hinc inde inflato-nodosa, vel tubercula fusiformia edens.

Subgen. 7. **Macrogyne.**—Sepala basi indurascentia, late hyalino-marginata. Petala integra, apice rotundata. Stamina 10. Discus crenato-lobatus, receptaculo sensim concavo enascens; glandulis distinctis staminiferis. Styli 2, longe exserti. Capsula oligosperma, 4 valvis dehiscens.—Herba nana perennis Yunnanensis, caulibus diffusis.

Subgen. I.—EUARENARIA.

Sectio i. Euthallæ.

Calyx basi haud indurascens; sepala (siccata) subenervia carinato-uninervia vel 3–5-nervia. Petala interdum nulla. Capsula ovoidea, calyce inclusa vel illo paullo longior, dentibus vel valvis dehiscens (dentibus quum 6 tum sæpius inæqualibus). Semina reniformi-globosa, globulosa, vel lenticularia, granulato-tuberculata (vel rarius scabro-rugulosa).—Herbæ amphigeæ, foliis latis vel angustis planis (nunquam elongato-gramineis setaceis nec lineari-filiformibus), axillis foliorum sæpe fasciculiferis; annuæ vel biennes, caule in cymam paniculæformem foliosam raro depauperatam soluto, aut suffrutescentes cæspitosæ, tunc caulibus sæpissime filiformibus, et flores nunc terminales et axillares solitarii, nunc per cymas depauperatas interdum abbreviatas (floribus itaque glomerato-capitatis) terminales dispositi.

Series A.—Stamina 10.

Subsectio 1.—Sepala uninervia vel (in vivo) enervia. Flores in cymas laxas paucifloras, in ramulis nonnullis interdum depauperatas ad florem unicum reductas, dispositi.

a. Petala calycem æquantia, vel eo longiora.

α. Species annuæ vel biennes.

† Folia obtusa vel apice rotundata.

A. conimbricensis, emarginata, nilghirensis, Pomeli.

†† Folia acuta.

A. obtusiflora, controversa, napuligera.

β. Species perennes.

(Axillæ caulium floriferorum fasciculos foliorum edentes.)

† Petala basi vix unguiculata.

A. hispida, lesurina, montana, grandiflora, valentina, cinerea, Huteri, tmolea, rotundifolia, Redowskii, libanotica.

†† Petala basi longe attenuata.

A. tomentosa, gracilis.

b. Petala calyce breviora.

α. Species annuæ.

A. gorgonea, Benthami.

β. Species perennes.

A. orbiculata, tenella.

Subsectio 2.—Sepala 3-nervia vel (siccata) 3–5-nervia. Flores in cymas laxas paucifloras vel effusas dispositi, vel ramorum apice solitarii, vel glomerato-capitati (cymis abbreviatis).

a. Petala calycem æquantia, vel eo longiora.

α. Species annuæ. Flores cymosi vel rarius solitarii.

† Folia uninervia, aut subtrinervia nervis lateralibus rudimentariis vel obsoletis. Sepala haud obtusa.

A. retusa, modesta, capillipes, oxypetala, pamphylica, sabulinea, algarbiensis, Liebmanniana.

†† Folia uninervia. Sepala apice incurva obtusa.

A. Loscosii, ciliaris.

††† Folia plurinervia. Sepala apice recta acuta.

A. conferta.

β. Species perennes.

† Flores solitarii, vel rarius cymis paucifloris (vulgo trifloris).

A. incrassata, racemosa, erinacea, tetraquetra, graveolens, filicaulis.

†† Flores glomerato-capitati,

A. Armeriastrum, capitata, pseudoarmeriastrum.

b. Petala calyce breviora.

α. Species annuæ vel biennes (*i. e.* monotocæ).

† Flores cymosi, in ramulis interdum depauperati ad florem unicum reducti.

A. serpyllifolia, leptoclados, cassia, nevadensis, tremula, macrosepala, conica, orbicularis.

†† Flores subsessiles, capitato-congesti. Capsula ovata sulcata.

A. nana.

††† Flores subsessiles, corymboso-fasciculati. Capsula anguste cylindrica.

A. Guicciardii.

β. Species perennes. Flores cymosi.

A. ovalifolia.

Series B.—Stamina 5.

A. andina, pentandra.

Sectio ii. SIKKIMENSES.

Calyx basi induratus; sepala (siccata ac in vivo) enervia. Petala majuscula. Stamina 10, rarius 5. Capsula ovoidea, calyce inclusa vel illo paullo longior, valvis dehiscens. Semina globulosa vel lenticularia, granulato-tuberculata, pallida, statu immaturo late alata.—Herbæ utplurimum Himalaïcæ, perennes cæspitosæ, caulibus non filiformibus, floribus terminalibus solitariis.

Series A.—Stamina 10.

Subsectio 1.—Folia margine incrassata aut nervoso-marginata. Calyx basi rotundatus.

A. ciliolata.

Subsectio 2.—Folia margine non incrassata neque nervoso-marginata. Calyx campanulatus.

a. Petala vix unguiculata.

A. Stracheyi, melandryiformis, bulica.

β. Petala in unguem attenuata.

A. Brotherana.

Series B.—Stamina 5, et staminodia 5.

A. nitida.

Sectio iii. LEIOSPERMÆ.

Calyx basi haud induratus; sepala carinata vel enervia. Petala interdum nulla. Capsula ovato-oblonga, calyce inclusa vel illo paullo longior, valvis dehiscens. Semina globoso-reniformia vel lenticularia, lævissima nitida, atra rarius rufa.—Herbæ perennes imprimis meridionali-Americanæ, caulibus interdum diffusis vel plus minus divaricato-ramosis flores axillares et terminales, solitarii vel rarius in cymas paucifloras aut dichasia composita dispositi.

Subsectio 1.—Flores solitarii, terminales et axillares.

A. muscoïdes, musciformis, Halacsyi, Balansæ.

Subsectio 2.—Flores solitarii axillares.

a. Sepala carinata, carinâ prominente pilosâ, margine ciliata, ceterùm glabra vel rarius puberula.

A. lanuginosa, megalantha, soratensis, pleurantha, parvifolia, reptans.

b. Sepala enervia puberula. (Petala nulla.)

A. Jamesoniana.

c. Sepala concava uninervia vel obsolete 3-nervia, glaberrima.

A. lycopodioides, Rohrbachiana.

Subsectio 3.—Flores solitarii, terminales.

A. Orbignyana, catamarcensis, achalensis, serpens.

Subsectio 4.—Flores axillares solitarii, et terminales subconferti.

A. microphylla, palustris.

Subsectio 5.—Flores longe pedicellati, in cymas paucifloras dispositi.

A. Stuebelii, saxosa, spathulata.

Subsectio 6.—Flores ad ramorum apicem conglomerati sessiles, vel dichasium valde compositum formantes.

a. Folia ovata obtusa. Sepala obtusa.

A. Mandoniana.

b. Folia angusta acuminata. Sepala acuta.

A. Peyritschii, Poeppigiana.

Sectio iv. PORPHYRANTHEÆ.

Calyx basi haud indurascens; sepala 3–5-nervia. Capsula cylindrica e calyce longe exserta, 6 dentibus brevibus æqualibus dehiscens. Semina compresso-globosa lævia fusca.—Herba perennis fruticulosa occidentali-Europæa, cæspitosa multiflora; foliis ovato-lanceolatis nitidis rigidulis. Flores in cymas terminales paucifloras dispositi, petalis roseis vel albis integerrimis.

A. purpurascens.

Sectio v. EREMOGONEÆ.

Calyx basi demùm induratus; sepala (siccata) subtrinervia. Capsula ovata, calyce inclusa, dentibus sero bifidis vel valvis bidentatis dehiscens. Semina compressa, pyriformia vel oblonga, lævia.—Herbæ amphigeæ perennes suffruticosæ cæspitosæ sæpe pulvinatæ, erectæ rigidæ: caudices lignosi, polycephali vel ramosi, caulibus floriferis elongatis strictis simplicissimis, basi imbricato-vaginatis cum turionibus brevissimis (interdum foliorum denudatis vel tantum squamatis), sæpius foliis setaceis lineari-

filiformibus vel subulatis apice in comam densatis, vegetis, et interdum ad axillas fasciculos foliorum edentibus; cyma terminalis simplex depauperata vel geminæ ternæ aut plures per thyrsum brachiatum paniculæ- vel corymbiformem illinc dispositæ, floribus sæpe congestis confertis vel glomerato-fasciculatis.

Subsectio 1.—Axillæ foliorum non fasciculiferæ.

A. Flores subsessiles, in cymis capitato-aggregatis vel glomerato-fasciculatis.

A. cephalotes, congesta, Franklinii, Hookeri, polycnemifolia.

B. Flores pedicellati, in cymas simplices aut compositas interdum depauperatas vel per thyrsum brachiatum paniculæ- vel corymbiformem dispositi, pedicellis calyci æquilongis vel longioribus suffulti.

a. Petala sepalis breviora.

A. pungens.

b. Petala calycem æquantia, vel sæpius eo longiora.

A. holostea, lychnidea, acutisepala, Szowitzii, compacta, isaurica, cucubaloides, juncea, saxatilis, longifolia, aculeata.

Subsectio 2.—Apud multa folia, axillæ fasciculos foliorum edentes.

A. drypidea, Ledebouriana, acerosa, Lessertiana, tetrasticha.

Subgen. II.—EREMOGONEASTRUM.

Sectio i.

Calyx basi haud indurascens. Flores solitarii, raro cymosi.

A. Bourgæi, festucoides, monticola, kansuensis.

Sectio ii.

Calyx basi induratus. Flores cymosi vel solitarii.

Subsectio 1.—Caules floriferi simplices, remote foliati; turiones foliis angustis dense comati multum breviores. Flores cymosi. Petala sæpius sepalis longiora.

A. scariosa, graminea, blepharophylla, Griffithii, armeniaca.

Subsectio 2.—Caules breves, dense foliosi, simplices vel ramulosi. Flores solitarii. Petala semper sepalis longiora.

A. polytrichoides, pulvinata, globiflora, densissima, kumaonensis, tetragyna.

Subgen. III.—PENTADENARIA.

Sectio i. Glomerifloræ.

Flores subsessiles, in cymis capitato-aggregatis vel glomerato-fasciculatis ; flore centrali sæpius ebracteato. Glandulæ emarginatæ.

A. Przewalskii, dianthoides.

Sectio ii. Rarifloræ.

Flores pedicellati, in cymas simplices aut compositas interdum depauperatas, vel per thyrsum brachiatum paniculæ- vel corymbiformem, dispositi, pedicellis calyci æquilongis vel longioribus suffulti ; bracteæ ochreaceæ subvaginantes scariosæ. Glandulæ integerrimæ.

Subsectio 1.—Folia lineari-setacea vel graminea, imprimis turionum. Semina lævia.

a. Sepala, præter nervum dorsalem viridem in mucronem haud excurrentem, flava vel albida.

A. rigida, graminifolia, Koriniana, oreophila, ferruginea, Tschuktschorum.

β. Sepala, nervo dorsali lato in mucronem herbaceum recurvo-patulum excurrente, picta vel subherbacea.

A. gypsophiloides, ursina, caricifolia, Roborowskii, capillaris.

Subsectio 2.—Folia imprimis caulina, lineari-setacea. Semina granulato-tuberculata.

A. macradenia, Fendleri.

Subsectio 3.—Folia ovata vel subrotunda. Semina scabra.

a. Petala sepalis longiora.

A. Saxifraga, ciliata, gothica, balearica, glanduligera.

β. Petala sepalis breviora, vel ea subæquantia.

A. biflora, Gayana.

Subgen. IV.—DICRANILLA.

Sectio i. Radiantes.

Petala calyce longiora. Stamina 10.

A. radians, dicranoides.

Sectio ii. Pycnophyllæ.

Petala calyce multum breviora, vel nulla. Stamina 10.

A. bisulca, bryoides, pycnophylla, pycnophylloides, boliviana.

Sectio iii. Pedunculosæ.

Petala calyce multum breviora, vel nulla. Stamina 5.

A. pedunculosa, Alpamarcæ.

Subgen. V.—ARENARIASTRUM.

Sectio i. Gouffeia.

Flores minuti, cymoso-paniculati. Stamina 10. Capsula oblonga vel subglobosa, calyce inclusa.—Herba Europæa biennis tenuis diffusa, foliis linearibus vel setaceis.

A. massiliensis.

Sectio ii. Lepyrodiclis.

Flores parvi, cymoso-paniculati. Stamina 10. Capsula inflato-globosa, calyce inclusa.—Herbæ Asiaticæ proceræ flaccidæ annuæ, foliis lanceolatis vel oblongo-lanceolatis.

A. holosteoides, tenera.

Sectio iii. Brachystemma.

Flores numerosi, in paniculis axillaribus vel terminalibus. Stamina 10, quorum 5 ananthera. Capsula depresso-globosa, calycem non superans. —Herba Himalaïca annua subscandens diffusa, foliis lanceolatis vel ovato-lanceolatis.

A. nepalensis.

Subgen. VI.—ODONTOSTEMMA.

Sectio i. Barbatæ.

Flores dichotomo-corymbosi, pedicellis elongatis erectis suffulti; bracteæ foliaceæ.

A. barbata.

Sectio ii. Yunnanenses.

Flores cymosi, pedicellis sub anthesi erectis mox deflexis suffulti; bracteæ foliaceæ.

A. yunnanensis, glandulosa, debilis, Delavayi, quadridentata.

Subgen. VII.—MACROGYNE.

A. longistyla.

IV. Descriptive Enumeration of the Species.

Subgenus I. EUARENARIA.

Sectio i. Euthaliæ.

Series A.—Stamina 10.

Subsectio 1.—Sepala uninervia vel (in vivo) enervia. Flores in cymas laxas paucifloras, in ramulis nonnullis interdum depauperatas ad florem unicum reductas, dispositi.

a. Petala calycem æquantia, vel eo longiora.

α. Species annuæ vel biennes.

† Folia obtusa vel apice rotundata.

1. A. conimbricensis, *Brot. Fl. Lusitanica*, ii. p. 200 (1804); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 621.

β. glanduloso-viscosa, *Webb*, ex *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 621; *Welw. herb.*, et in litt. 1847.

Geogr. area. Spain and Portugal.

N. & E. Monistrol, in Catalonia.

S. Niebla, in Andalusia.

W. Coimbra, in prov. of Beira, and Serra de Monchique in prov. of Algarve.

Iconogr.—*Brot. Phytogr. Lusit. Sel.* p. 179, t. 73; *Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 91, t. 61 a.

Syn. *Spergula ciliaris*, Brot. Fl. Lusitanica, ii. p. 215 (1804).

2. A. emarginata, *Brot. Fl. Lusitanica*, ii. p. 202 (1804); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 622.

Habitu similis *A. modestæ*, a qua antheris conspicue olivaceis; petalis emarginatis roseis, sepalis foliisque obtusis bene distincta est.

β. Salzmanni, *Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 94, t. 62 c. Staturâ major. Flores duplo majores. Petala ovato-oblonga patentissima profundius emarginata, basi repente in unguem brevissimum contracta. Capsula paullo angustior, cylindraceo-conica.

In Gay's MS. note on this plant, which he obtained from Salzmann, he says that the alternate filaments are saccate at the base; though, in examining the specimens, I could not find any

evidence of enlarged glands attached to the inner series of filaments, a character which would warrant the transference of the plant to the subgenus *Pentadenaria.* Specimens of this species, accidentally placed in a parcel of Greek plants in Fauché's herbarium, were described as a new species by Chaubard under the name of *A. sordida.* The eastern limit of the species is determined from the specimens in the late Mr. G. C. Joad's herbarium.

Geogr. limits.—N. & W. Portugal: Faro in the prov. of Algarve.
E. Near Algiers (*Herb. Joad*, 1873).
S. Algeria: Andalous in the dept. of Oran (*Balansa*, Pl. d'Algérie, 1852, no. 452).

Iconogr.— *Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 93, t. 62 B, et p. 94, t. 62 C (var. β); *Chaub. Fl. Péloponn.* n. 699, t. 24. f. 1 (*A. sordida*).

Syn. *A. bætica*, Salzm. *ex* Ball, in Journ. Linn. Soc. xvi. p. 365 (1877).

3. A. nilghirensis [neelgherense], *Wight & Arn. Prodr. Fl. Ind. Or.* p. 43 (1834); *Hook. f. Fl. Brit. Ind.* i. p. 239.

Hab. N.W. Himalaya in Kashmir, and Nilghiri Hills in Malabar; also Belgaum and Dharwar in Bombay Presidency (*Dalz. & Gibs.* Bomb. Fl. p. 15 [1861]),—not mentioned in Hooker's 'Flora of British India.'

Wight says that it is only met with here and there in the Nilghiri Hills, and is not at all common. This locality remains the southern limit of the genus, which is 11° N. lat.

Iconogr.— *Wight, Ic. Pl. Ind. Or.* 949, et *Spicil. Neilgherr.* t. 15.

4. A. Pomeli, *Munby, in Bull. Soc. Bot. France,* xi. p. 45 (1864); *Pomel, Nouv. Mat. Fl. Atlant.* p. 207.

Pumila, glauca, 4–10 * centim., sæpius a basi ramosa, ramis erectis. Caules dense puberuli pilis brevibus retrorsis, simplices flore unico terminati vel sæpius superne dichotome ramosi, ramis dichotomiæ simplicibus flore terminatis vel iterum dichotome divisis, ramo altero dichotomiæ abortu sæpe deficiente. Folia glabra punctulato-tuberculata, margine scabra, nervo medio breviter dentato; inferiora oblongo-spathulata, media et superiora

* The stem-measurements throughout are taken with a centimetre measure from good average specimens; and in French authorities these of course usually agree with the length given in the original description.

obovato-oblonga vel oblongo-lanceolata sessilia. Flores in cymam laxam dispositi, alares longe pedicellati. Sepala erecta acuta inæqualia; exteriora 2 late ovata carinata, intermedium ovato-oblongum, nervo valido denticulato, interiora 2 obovato-oblonga carinata. Petala oblongo-linearia integerrima alba, calycem æquantia. Capsula ovato-globosa, apice dentibus 6 dehiscens. Semina compresso-subglobosa, obtuse tuberculata.

A. spathulata huic affinis, sed præsertim differt pube glandulifera viscosâ, sepalis hispidis æqualibus oblongo-lanceolatis 5-nerviis marginato-membranaceis, petalis obovatis calyce duplo longioribus, et seminibus minute ruguloso-tuberculatis.

Hab. Algeria: Gharrouban and Afir in dept. of Oran.

Iconogr.—*Coss. Illustr. Fl. Atlant.* fasc. iii. (1890), p. 151, t. 98.

†† Folia acuta.

5. A. OBTUSIFLORA, *Kunze, Chloris Austro-Hisp.* in *Flora*, xxix. (1846) p. 632; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 621.

Similis *A. modestæ*, hæc autem differt foliis paullo magis pubescentibus, sepalis trinerviis valde acutis, petalis calycem subæquantibus, seminibus breviter tuberculatis: etiam a Boissier (in *Pugill. Plant.* p. 23) cum *A. conimbricensi* perperam conjuncta est; differt ab ea caule altiore, ramis filiformibus erectis gracilioribus pedicellisque glabris vel sub lente minutissime puberulis, foliis lineari-lanceolatis breviter acutis conspicue uninerviis, floribus minoribus in cymâ repetito-dichotomâ regulari dispositis, sepalis obovato-oblongis, antheris luteis.

Geogr. range.—*N. & E.* Sierra de Chiva, in prov. of Valencia, where it was first collected by C. Boutelou, and recorded by him under the name of *A. saxatilis*, Linn.
S. & W. Peña Alta near Velez-Rubio, in prov. of Andalusia (*Rouy*, 1881).

A rare but distinct species found only in S.E. Spain.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 91, t. 61 B.

SYN. *A. saxatilis* (non Linn.), Bout. *ex* Willk. et Lge. Prodr. Fl. Hisp. iii. p. 621.

6. A. CONTROVERSA, *Boiss. Voy. Bot. Esp.* p. 100 (1839); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 622.

Although Gay compares his *A. tenuis* with *A. modesta*, an examination and comparison of the type-specimens in Herb. Kew. unmistakably show them to be identical with *A. controversa*. The specimens collected by Porta and Rigo in 1891 (exs. no.

414) on the Sierra de Alcaraz in Murcia, and the specimens collected by Bourgeau (named *A. tenuis*) in the same locality, are identical.

Geogr. limits.—N. France: dept. of Vienne

E. Central France.

S. Spain: Sierra de Alcaraz, in prov. of Murcia.

W. Spain: near Valladolid, in prov. of Leon.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 92, t. 61 C: *Delastre, Fl. départ. Vienne*, p. 120, t. 2 (*A. conimbricensis* var.).

SYN. *A. tenuis*, J. Gay, in Walp. Ann. Bot. vii. p. 300 (1867).

A. conimbricensis, J. Gay, *ex* Gren. et Godr. Fl. de France, i. p. 260.

A. Gouffeia, Puel, in Duch. Rev. Bot. i. p. 450 (1846).

7. A. NAPULIGERA, *Franch. in Bull. Soc. Bot. France*, xxxiii. p. 429 (1886); *Pl. Delavay.* p. 92, t. 24 A.

Radix inflata fusiformis, e collo unicaulis vel multicaulis. Caules rubescentes unilateraliter puberuli, plus minus dichotome ramosi, ramis intricatis. Folia linearia vel lineari-oblonga, punctis elevatis asperata, basi ciliolata, ceterum glabra. Inflorescentia paniculato-corymbosa; pedunculi rigidi erecti, inferiores solitarii, superiores 3–5. Calyx purpurascens; sepala lanceolata vel ovato-lanceolata, obtusa, margine membranacea. Petala rosea, calyce duplo longiora, obovata, emarginata vel breviter biloba. Ovula 10–14.

A handsome plant with large rose-coloured flowers, well characterized by its napiform root, very large in some specimens, less developed in others. It cannot be compared with any Himalayan species: its habit is rather that of certain annual European species, such as *A. controversa*, with more specious flowers, which are rose-coloured instead of white.

Hab. China: prov. of Yun-nan, in fissures of Mt. Koua-la-po, near Hokin (1884); and on the road to the hill of Yen-tze-hay near Lankong, at 2500 metres.

Iconogr.—*Franch. Pl. Delavay.* p. 92, t. 24 A.

β. Species perennes
(axillæ caulium floriferorum fasciculos foliorum edentes).

† Petala basi vix unguiculata.

8. A. HISPIDA, *Linn. Sp. Plant.* p. 425 (1753); *Willk. & Lange, Prodr. Fl. Hisp., Supplem.* p. 277 (1893).

The Linnean specimens were from the neighbourhood of Montpellier. It is not an "espèce exclusivement française," as claimed by Rouy and Foucaud (Fl. de France, iii. p. 244 [1896]), since it is found on the Spanish side of the Pyrenees. The stems are from 10–20 centim.

Geogr. limits.—*N.* Depart. of Aveyron. *E.* Depart. of Gard. *S. & W.* On Mt. Costabona, in Catalonia (not usually marked in maps).

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 97, t. 65 B; *DC. Ic. Pl. Rar. Gall.* 47; *Cus. & Ansb. Herb. Fl. France,* iv. t. 701.

9. A. LESURINA, *Loret, Herb. Lozère*, p. 13 (1858–62); *Lecoq et Lam. Cat. Pl. Centr. France*, p. 104 (1847), *sub* A. ligericina.

Caules simplices vel ramosi, teretes erecti subfastigiati, 5–7 centim. Folia inferiora approximata subimbricata ovali-lanceolata acuminata uninervia læte virentia. Flores parvi in cyma dichotoma, terminales longe, alares brevius pedicellati; pedicellis florum alarium bracteolatis. Sepala ovato-lanceolata acuta anguste membranaceo-marginata. Petala suborbiculata pallide lutea calyce parùm longiora. Capsula in valvas 6 lanceolatas profunde dehiscens. Semina reniformi-globosa grosse et obtuse tuberculata.—Tota planta indumento patulo glanduloso-viscoso dense vestita.

The earlier name of *A. ligericina* is rejected, as it is the Latin name for the River Loire, instead of that for Lozère, which the author intended.

Hab. France: departments of Lozère and Aveyron.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 99, t. 66 A (A. ligericina); *Cus. & Ansb. Herb. Fl. France,* iv. t. 696 (A. ligericina).

10. A. MONTANA, *Linn. Cent. Plant.* i. p. 12 (1755); *Amœnit. Acad.* iv. p. 272; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 623.

Syn. Præ-Linnæana.—Alsine foliis linearibus acuminatis, petalis florum integris calyce duplo longioribus, *Le Monnier, Catalogue des Plantes en Auvergne, etc.* (1744).

Myosotis lusitanica linariæ folio, magno flore, *Tournef. Inst. Herb.* p. 244, ex auct. herbarii Vaillant.

Le Monnier wrote that it occurred plentifully on the road from Orleans to Bourges, especially in the forest of Alloigni. He is the first botanist to give a satisfactory account of the plant.

β. saxicola, *Rouy, Exc. Bot. Esp.* iii. p. 38 (*ex Bull. Soc. Bot. France*, xxxi. [1884]).

Folia sepalaque latiora dense pubescentia candicantia.

Hab. Valencia: Mt. Mongo, Bernia, and Cabo de S. Antonio.

γ. intricata, *Ser. in DC. Prodr.* i. p. 410.

Læte virens. Caules ramosiores fragiles cæspitem laxum imbricatum formantes. Folia linearia glabrescentia. Sepala glabra.

Hab. Provinces of Andalusia, Murcia, and Valencia.

According to Saccardo and Bizzozzero this variety has been found in the Venetian Alps, but Maratti's specimens are imperfect, and the record has never since been verified. They may be identical with *A. grandiflora*, as the locality given is Mt. di Lozzo.

Geogr. limits.—*N.* Dept. of Eure, near Evreux (*Morière*, Fl. Norm.). *S.* Prov. of Andalusia.
E. Dept. of Hérault. *W.* S. Portugal.

Iconogr.—*Reichb. Ic. Fl. Germ. Helv.* 4951; *Asso, Syn. Stirp. Arrag.* n. 383, t. 2. f. 3 (1779); *Bot. Mag.* t. 1118; *The Garden*, Dec. 1893; *Cus. & Ansb. Herb. Fl. France*, iv. t. 693; *Vent. Hor. Cels*, t. 34.

Syn. *A. linearifolia*, Poir. Encycl. vi. p. 366.
A. pyrenaica, Hort. *ex* Steud. Nomencl. ed. 2, i. p. 126.
Bigelowia montana, Rafin. in Journ. Phys. 1819, p. 289.

11. A. grandiflora, *Linn. Syst. Plant.* ed. X. p. 1034 (1759); *Sp. Plant.* ed. II. p. 608 (1762); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 624, et *Supplem.* p. 277.

α. genuina, *Rouy & Fouc. Fl. de France*, iii. p. 251 (1896).

Caules 1–2-flori. Folia omnia linearia vel anguste lanceolata, plana rigida.

β. abietina, *Presl* (sp.), *Delic. Prag.* i. p. 63; *Fl. Sicula*, p. 164.

Caules 1–2-flori. Folia omnia linearia vel anguste lanceolata, revoluta.

γ. mixta, *Lapeyr.* (sp.) *Hist. abr. Pl. Pyr.* i. p. 255; *Rouy & Fouc. Fl. de France*, iii. p. 251.

Caules 2–6-flori fastigiati. Folia stricta vel paullo patentia recurva; inferiora lineari-subulata plana, reliqua lanceolata.

δ. triflora, *Linn.* (sp.) *Mant. Plant.* p. 240 (1771).

Linnæus gives a clear and full description of this plant in the second portion of his 'Mantissa Plantarum': Caules palmares, copiosi, diffusi, adscendentes, teretes, subpubescentes: ramis alternis erectis. Folia lanceolato-subulata (juniperina), patentia, acuminata, ciliata, subtus pubescentia: floralia ovato-lanceolata, subtus pilosa. Pedunculi terminales, plures, teretes, pubescentes, articulis caulinis longiores, triflori; pedicellus intermedius aphyllus, laterales longiores; bracteis duabus, ovatis, ciliatis, extus pubescentibus. Calyx ovatus, acutus, erectus, pubescens. Petala obovata, oblonga, calyce duplo longiora, patentia, obtusa, alba, lineata. Stamina alba. Pistillum viride staminibus brevius.

The following more or less intergrading forms of this variety are worked out from the material in the Vienna Herbarium, consisting of the specimens from Fenzl's own herbarium. They differ in minor details when placed side by side, but are rather difficult to separate satisfactorily by definition:—

Lusus 1 (parviflorus). Humilis. Confertim et pulvinatim cæspitosa, caudiculis lignescentibus. Cauliculi 1–3-flori stricti 12–35 mm. Folia imbricato-congesta, erecta vel patula, anguste subulata. Calyx 3 mm.
Hab. Depart. of Pyrénées-Orientales.

Lusus 2 (angustifolius).

Forma *humilis.*—Differt a præcedente florum magnitudine, sepalis magis ovato-oblongis quam late ovatis.
Hab. Switzerland.

Forma *stricta.*—Læte viridis, plerumque late cæspitosa. Folia plerumque stricta, remotiora ac magis patula vel recurva.
Hab. Switzerland: Mt. Chasseron in the Jura, canton Vaud.

Forma *intermedia.*—Caudiculi cauliculique magis elongati, sæpe 2–3-flori. Folia fasciculorum magis patula tamen rigida.
Hab. Switzerland: canton Vaud.

Forma *flaccida.*—Læte viridis. Cauliculi plerumque multiflori elongati. Folia flaccida varie patula vel recurvata.
Hab. Switzerland.

Forma *glauca.*—Præcedente, etiam rigidior, eximie glauca.

Lusus 3 (latifolius).

Forma *heterophylla*.—Laxe cæspitosa. Folia flaccida quam typo (*α*) majora latiuscula, juniora angustissima fere setacea.

Hab. Montpellier, Mt. Ventoux, and Val d'Eynes in the Pyrenees.

Forma *elongata*.—Cauliculi valde elongati 3–7-flori. Folia inferiora stricta, superiora flaccida.

Hab. Sierra Nevada in Andalusia; Vallée de Cervières, in depart. of Aveyron (*A. minor*, Decne., and *A. triflora*, Willd.).

ε. multiflora, *Ser. in DC. Prodr.* i. p. 404.

Caules 3–4-flori. Folia lineari-subulata rigida ciliolata.

Possibly the same as lusus 2 forma *stricta* of preceding var., but the leaves uniformly ciliolate instead of only towards the base.

ζ. stolonifera, *Vill. Journ. Mens.* p. 437 (MSS.) ap. *Verlot, Pl. Dauph.* p. 62; (sp.) *Vill.* ex *DC. Prodr.* i. p. 404.

Caules florigeri 1–2-flori surculis multis sterilibus intermixti. Folia rigida, inferiora subulata, reliqua lanceolato-linearia.

η. aculeata, *Willk. Prodr. Fl. Hisp., Supplem.* p. 277.

Syn. *Stellaria aculeata*, Scop. Fl. Carniol. (ed. 2) i. p. 316.

Hab. Andalusia: Sierra de Alfacar and Sierra de Peñagolosa.

This polymorphous species varies considerably within narrow limits. The forms have been grouped into seven varieties on the characters of the length, breadth, and direction of the leaves, the size of the flowers, and the number of pedicels springing from one axis. The leaves are frequently imbricated on the stem, but never tetrastichous. Cosson proposed to sink *A. incrassata* also in this species; but in typical specimens of *A. grandiflora* the stem is distinctly 4-angled, especially in vigorous specimens with furrowed surfaces between the angles; the seeds also are more distinctly tuberculate. In one of the specimens growing this year in the Alpine house at Kew Gardens, most of the flowers had 4 styles.

Geogr. limits.—*N.* Austria: Mt. Pollauer and the Nikolsberg in West Moravia.

S. Alpine stations in Sicily up to 1500 metres (*Lojacono*).

E. Croatia.

W. Corunna in Spain (*Guardia*, ex herb. Groves).

This is a species widely distributed in Central and Southern

Europe, but it is doubtful whether its range extends so far east as Transylvannia, as stated by Schur.

Iconogr.—*All. Fl. Pedem.* n. 1711, t. 10. f. 1 ; *Ic. Taurn.* xiv. t. 73. f. 7 ; *Pedem. Stirp. Spec.* p. 49, t. 10. f. 1 (1755) ; (var. β) *Reichb. Ic. Fl. Germ. Helv.* 4946 ; (var. η) *Reichb.* l. c. 4946 β; *Scop. Fl. Carniol.* (ed. 2) n. 527, t. 17 (*Stellaria aculeata*).

Syn. *A. capillacea,* All. Fl. Pedem. ii. p. 365 (=var. *a*).
A. graminea, Steud. Nomencl. ed. 2 i. p. 124 (=var. *a*).
A. juniperina, Vill. Hist. Pl. Dauph. iii. p. 624 (=var. ε).
A. juniperina, Thuill. Fl. Env. Paris, p. 218 (=var. δ).
A. laricifolia (*non* Linn.), Lapeyr. Hist. abr. Pl. Pyr. p. 255 (=var. *a*).
A. laxa, Fisch. *ex* Ser. in DC. Prodr. i. p. 404 (=var. *a*).
A. liniflora (*non* Linn.), Willd. *ex* Spreng. Syst. Veg. ii. p. 399 (=var. *a*).
A. montana (*non* Linn.), All. Fl. Pedem. ii. p. 112 (=var. *a*).
A. saxatilis (*non* Linn.), Lapeyr. Hist. abr. Pl. Pyr. p. 234 (=var. *a*)

12. A. valentina, *Boiss. Diagn. Pl. Or. Nov.* Ser. II. i. p. 90 (1854) ; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 625.

Fruticulosa. Caules diffusi filiformes flexuosi teretes retrorsum papilloso-puberuli, alternatim ramosi, sæpe intricati. Folia lineari-subulata areolata-punctata, margine revoluta, subtus nervo valido instructa, basi ciliata ceterùm glabra, rigida sed vix pungentia, patula vel recurva. Sepala ovata longe acuminata glabra, exteriora anguste, interiora late membranaceo-marginata. Petala oblongo-spathulata, calyce duplo longiora. Capsula valvis 6 dehiscens. Semina compresso-reniformia, obscure et obtuse tuberculata.

According to C. Pau, this plant is identical with *A. montana* var. *intricata,* which occurs in the northern part of the province of Valencia. But specimens of true *A. valentina,* which hitherto have been found only in the southern part of the province, certainly seem to differ from this variety of *A. montana.* Intermediate forms have not been collected.

Hab. Spain : southern part of prov. of Valencia.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 97, t. 75 A.

13. A. cinerea, *DC. Fl. Franç., Supplem.* p. 611 (1815) ; *Rouy & Fouc. Fl. de France,* iii. p. 245 (1896).

18 centim., cinereo-pubescens. Caules di-trichotomi diffusi. Folia inferiora oblongo-lanceolata basi plus minus ciliata, superiora lanceolata-linearia, omnia acuta uninervia ; axillis inferioribus

fasciculiferis. Flores dichotome paniculati; pedicelli calyce 5–6-plo longiores. Calyx ovato-cylindricus; sepala lanceolata acuta, margine basi ciliata, nervo post anthesin ciliato denticulato, interiora late scarioso-marginata, cetera anguste scarioso-marginata. Petala apice rotundata obtusa, calyce duplo longiora. Antheræ aurantiacæ. Capsula ventricosa ovoidea, calycem superans. Semina reniformia, dorso convexa, faciebus leviter excavata, obtuse tuberculata.

Prope *A. hispidam*, quæ staturâ minore, pubescentiâ longiore glanduloso-viscosâ, foliis lineari-lanceolatis glabris, pedicellis refractis, seminibusque duplo minoribus acuteque (nec obtuse) tuberculatis ab ea statim dignoscitur.

Described from specimens gathered at Castellane, in the department of Basses-Alpes. Included by E. Tanfani in Parlatore's 'Fl. Italiana,' but all the localities given are in French territory.

Hab. S.E. France: departs. of Basses-Alpes and Alpes-Maritimes.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp* i. p. 96, t. 64.

Syn. *A. ruscifolia,* Requien, in Guer. Vaucl. ed. 2, p. 254.

14. A. Huteri, *Kern. in Oesterr. Bot. Zeitschr.* 1872, p. 368; *Tanf. in Parl. Fl. Italiana,* ix. p. 541.

Glanduloso-pubescens. Caules decumbentes, congesti in cæspitem laxum. Folia oblongo-lanceolata vel spathulata acuta uninervia ciliata. Flores solitarii vel geminati, rarissime dichasium triflorum efformantes; pedicelli calyce 3–5-plo longiores, glanduloso-pubescentes. Sepala anguste oblonga obtusiuscula navicularia anguste membranaceo-marginata pubescentia ciliata subenervia. Petala alba, late obovata, calyce duplo longiora, post anthesin fauce recurva. Antheræ pallide purpureæ. Semina reniformi-globosa granulata.

Affinis *A. gracili,* quæ differt cæspitibus densis, caulibus pedicellisque erectis glabris, foliis viridibus, bracteis subulatis, sepalis ovato-lanceolatis glabris lævibus, petalis basi longe attenuatis.

α. rupestris, *Huter & Porta,* exsicc. 1873.

β. glareosa, *Huter & Porta,* exsicc. 1873.

Var. β minus cæspitosa. Folia magis acuta. Flores sæpius geminati.

Described from authentic living specimens *in situ,* which flowered in Kew Gardens in 1896. It is quite distinct from *A. grandiflora* and *A. gracilis.*

Hab. Confines of S. Tyrol and Venetia at 700–1900 metres; along the Cimolais Canal at Serra delle Gotte, Valley of Inferna, Valley of Bricca, Val Zelline in Udine, and (β) at Serra della Fontana.

Iconogr.—*Journ. Hortic.* ser 3, xxix. p. 369.

15. A. TMOLEA, *Boiss. Diagn. Pl. Or. Nov.* Ser. I. i. p. 50 (1842); *Fl. Orient.* i. p. 698.

β. macropoda, *Haussk.* pl. exs. in *P. Sintenis, It. Orientale,* 1890, no. 2844 *b.*

Planta puberula, 31 centim., floribus regulariter cymosis. Caudiculi longi. Folia 3-nervia.

Hab. Turkish Armenia: Egin, in prov. of Diarbekir.

γ. Sintenisii, *Haussk.* pl. exs. in *P. Sintenis, It. Orientale,* 1890, no. 2844.

Planta fere glabra, 18 centim., clarescenti-viridis. Bracteæ acuminatæ. Petala calyce duplo longiora.

Hab. Turkish Armenia: Egin, in prov. of Diarbekir.

δ. Kotschyana, *Fenzl* (sp.), *in Russegg. Reise,* ii. p. 930 (1843); *Boiss. Fl. Orient.* i. p. 699.

Folia sæpius glabra lanceolata vel linearia, nervis subtus magis prominentibus. Scapi 2–5-flori. Sepala sæpius glabra, elevatius carinata.

Hab. Mt. Taurus, in Cilicia; and at Egin with the other two varieties (*P. Sintenis,* It. Orient. 1890, no. 2685).

Geogr. range.—N. Mt. Ak-dagh, in prov. of Siwas (*Bornmüller,* 1889, no. 990).

E. Turkish Armenia: Egin, in prov. of Diarbekir.

S. & W. Mt. Budrun (Halicarnassus), in Anatolia.

This species ascends to 3000 metres on Mt. Beryt-dagh, in the prov. of Marash.

16. A. ROTUNDIFOLIA, *Bieb. Fl. Taur. Cauc.* i. p. 343 (1808); *Boiss. Fl. Orient.* i. p. 700.

β. colchica, *Alboff, Prodr. Fl. Colch.* p. 36 (1895).

Densius cæspitosa, microphylla, nana. Caules 1–3 centim. Folia ovata. Cymæ 1–3-floræ, rarius subunifloræ; floribus minutis.

Hab. Mt. Lekudeli in Mingrelia, and Mt. Okhaczkue above Samurzakania.

It has been observed in this species that, with the growth of

the branches of the stem and the lengthening of the internodes, the fasciculate leaves become discrete, so that it may be seen that between two pairs of large fully-developed leaves several pairs of smaller leaves are intercalated. Where the branches remain short and undeveloped, so that the upper portion of the flowering stem does not branch out, the stems are few-flowered, and such specimens were referred by Grisebach to *A. biflora*. Boissier, however, very properly referred them to this species, reducing them to the variety next mentioned.

γ. pauciflora, *Boiss. Fl. Orient.* i. p. 700.

Rami multùm abbreviati 1–2-flori.

Hab. Mt. Olympus in Thessaly, and Mt. Scardus in Rumelia.

Geogr. limits.—*N.* Mt. Kazbek, in the Central Caucasus, at 2530 metres (*C. A. Meyer*, 1829).

S. Mt. Taurus, in Cilicia (*Kotschy*).

E. Afghanistan: district of Badakshan (*Regel*, It. Turkestan. 1882).

W. Montenegro: summit of Savin-Kuk, a peak of Mt. Durmitor (*Baldacci*, in Malpighia, 1891, p. 65); also in Albania, Mt. Nimercka in the district of Premeti (*Baldacci*, in Bull. Herb. Boiss. 1896, p. 619).

Syn. *A. biflora* (*non* Linn.), Griseb. Spicil. Fl. Rumel. Bithyn. i. p. 203.
A. transsilvanica, Simk. in Termés. Füz. x. 1886, p. 180.
Euthalia rotundifolia, Rupr. Fl. Caucasi, p. 220.

17. A. Redowskii, *Cham. et Schlecht. in Linnæa*, i. p. 58 (1826); *Ledeb. Fl. Rossica*, i. p. 370.

Habitu etc., *A. ciliatam* revocat, sed caudiculis brevibus ramosis, caulibus floriferis simplicibus plerumque erectis gracilibus 1–2-floris, foliis caulinis remotioribus subacuminatis.

The species was founded on Kamtschatka specimens. Regel, who was able to examine specimens from other localities for the purpose of figuring the plant, draws attention to the 1-nerved sepals, and says that the petals are ovate-subrotund, not obovate-cuneate as in the original description, which must have been drawn up from more shrivelled specimens.

Geogr. limits.—E. Siberia.

N. & W. Between Jakutzk and Ochotzk.

E. Kamtschatka. *S.* Ayan, on the coast.

Iconogr.—*Regel, Pl. Raddeanæ*, t. 9, *in Bull. Soc. Nat. Mosc.* 1862.

18. A. LIBANOTICA, *Kotschy, in Boiss. Fl. Orient.* p. 699 (1867); *Post, Fl. Syr.* p. 153 (1896).

Nana, tantum 22 mm. supra terram. Folia glabrescentia minima obovata carinata obtusa ad basin ramorum imbricata. Rami floriferi breves glanduloso-velutini 1–3-flori. Pedicelli calyce longiores. Sepala ovata obtusa glanduloso-hirsuta. Petala alba obovata calyce longiora.

Distinguished specifically by the small leaves imbricated at the base of the short branches. Mr. Post does not seem to have been able to obtain specimens, since he has not added any fuller characters to Boissier's somewhat fragmentary description. It is certainly one of the smallest species in the genus.

Hab. Mt. Lebanon, in Syria.

†† Petala basi longe attenuata.

19. A. TOMENTOSA, *Willk. in Linnæa*, xxv. (1852) p. 15; *Prodr. Fl. Hisp.* iii. p. 626.

Suffruticosa, tota crispato-tomentosa, cæsio-canescens. Caules breves pumili erecti, simplices vel patule ramosi, teretes, cæspitem compactum fastigiatum formantes. Folia minuta 4-fariam imbricata oblonga obtusa recurva, nervo albido marginata, dorso nervoso-carinata. Flores 2–5 ad apicem cauliculorum aggregati, alii capitati, alii sub capitulo solitarii axillares; bracteæ ovato-lanceolatæ obtusæ. Sepala inæquilonga lanceolata acuminata anguste membranaceo-marginata. Petala alba spathulata, calycem parum superantia.

Hab. Sierra Nevada in Andalusia, on the peak between Las Vertientes and Chirivel up to 1200 metres.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 98, t. 65 D.

20. A. GRACILIS, *Waldst. et Kit. Pl. Rar. Hung.* iii. p. 305, t. 276 (1812); *Schloss. et Vukot. Fl. Croat.* p. 352.

β. cretica, *Spreng.* (sp.), *Syst. Veget.* ii. p. 396.

Superne glanduloso-hirtella. Folia elliptico-oblonga. Sepala oblongo-lanceolata.

γ. intermedia, *var. nov.*

Minus cæspitosa, 7–9 centim., puberula. Folia linearia magis acuta, margine scabra. Sepala ovalia. Petala oblonga apice rotundata (*Vandas*, Fl. Herceg. australis, exsicc. 1891).

δ. Stygia, *Boiss. & Heldr.* (sp.) *Diagn. Pl. Or. Nov.* Ser. II. i. p. 91 (1854); *Boiss. Fl. Orient.* i. p. 699.

Tota planta breviter velutino-viscida.

Geogr. limits.—*N.* Croatia. *S.* Cyprus.
E. Cyprus. *W.* Dalmatia.

Iconogr.—*Waldst. & Kit. Pl. Rar. Hung.* iii. t. 276; *Sibth. Fl. Græca*, t. 438 (A. ciliata); *Reichb. Ic. Fl. Germ. Helv.* 4945.

SYN. *A. densa*, Kit. *ex* Schlecht. in Gesellsch. naturf. Fr. Berl. Mag. vii. p. 200 (1813).

A. hirta (*non* Wormsk.), Sieber, *ex* Oken, Isis, 1828, p. 272 (=var. β).

b. Petala calyce breviora.

a. Species annuæ.

21. A. GORGONEA, *J. A. Schmidt, Beitr. Fl. Cap. Verd. Ins.* p. 278 (1852); *Walp. Ann. Bot.* vii. p. 298.

Glutinosa, pilis glanduliferis patentibus obsita. Caules ramosissimi adscendentes teretes subflexuosi. Folia acuta, inferiora in petiolum brevem attenuata ovato-oblonga, superiora ovato-lanceolata, margine ciliolata. Flores dichotomi. Sepala lanceolata acuminata, anguste membranaceo-marginata, apicibus recurva, petalis subduplo longiora. Petala alba ovata. Capsula valvis 6 dehiscens. Semina reniformia rugosa nigra.

Planta *A. serpyllifoliam* revocat, sepala autem uninervia et inter se homomorpha.

Hab. In sugar plantations, on the island of São Antão (St. Anthony) of the Cape Verd Islands, lat. 17°, long. 25° (1851).

This interesting endemic species is quite distinct from any of the forms of *A. serpyllifolia.*

22. A. BENTHAMI, *Fenzl, in herb. Benth.*, ex *Torr. & Gray, Fl. N. Amer.* i. Suppl. p. 675 (1840); *A. Gray, Pl. Wright.* ii. p. 18.

β. diffusa, *var. nov.*

Caules uno latere pubescentes, ramosi, 10–15 centim. Folia caulina cuspidato-acuminata subpungentia. (*Heller*, Pl. of S. Texas, no. 1686.)

Hab. Bear Creek, Kerr County (April 1894).

Geogr. area. S. United States: Texas and New Mexico.

SYN. *A. monticola*, Buckl. in Proc. Acad. Sc. Philad. 1861, p. 449.

β. Species perennes.

23. A. ORBICULATA, *Royle*, ex *Hook. f. Fl. Brit. Ind.* i. p. 240 (1874) ; *Duthie, List N. W. Ind. Pl.* p. 22 (1881).

Caules a basi ramosi ; rami tenues dichotomi decumbentes fere glabri, 5–50 centim., uno latere lineato-puberuli. Folia orbiculata uninervia obtusa vel apiculata glabriuscula. Flores solitarii vel in cymis paucifloris. Sepala glabra, ovata vel lanceolata, nervo vix manifesto. Petala alba. Capsula valvis 3 bidentatis dehiscens. Semina reniformia, subtiliter granulata.

SYN. *A. serpyllifolia*, var., in herb. Royle.
A. muralis, Edgew. herb.

Geogr. limits.—Temperate Himalaya.

N. Ballal in Kashmir. *S.* Sikkim.
E. Bhutan. *W.* Kulu District of the Punjaub.

24. A. TENELLA, *Duthie, ined. in Pl. Kumaon*, 1884, no. 2763.

Caules simplices, 9–12 centim., tenelli, breviter puberuli. Folia spathulato-linearia uninervia acuminata papilloso-punctata glabriuscula. Flores solitarii, axillares et terminales. Sepala ovata subacuta papilloso-punctata subenervia late membranaceo-marginata. Petala obtusa.

Hab. N.W. India : Ralam Valley in Kumaon.

Described from specimens in Herb. Mus. Brit.

Subsectio 2.—Sepala 3-nervia vel (siccata) 3–5-nervia. Flores in cymas laxas paucifloras vel effusas dispositi, vel ramorum apice solitarii, vel glomerato-capitati (cymis abbreviatis).

a. Petala calycem æquantia, vel eo longiora.

α. Species annuæ. Flores cymosi vel rarius solitarii.

† Folia uninervia, aut subtrinervia nervis lateralibus rudimentariis vel obsoletis. Sepala haud obtusa.

25. A. RETUSA, *Boiss. Voy. Bot. Esp.* p. 99, t. 27 A (1839) ; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 622.

Hab. Sierra Nevada, in Andalusia.

Iconogr.—*Boiss. l. c.*

26. A. MODESTA, *Duf. in Ann. Sc. Gén. Phys.* vii. p. 291 (1820) ; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 622.

Forma *typica*. Semina obtuse tuberculata.

β. trachysperma, *Willk.* Semina acute tuberculata.

Species valde glutinosa, a formâ viscoso-pubescente *A. obtusifloræ* caute distinguenda.

Included in Parlatore's 'Fl. Italiana,' apparently for the ethnographical reason that it occurs in Corsica.

Geogr. limits.—*N.* France: dept. of Gard. *E.* Corsica.
S. Andalusia: Sierra Nevada, up to 1800 metres.
W. Andalusia: near Granada.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* p. 91, t. 62 A.

27. A. CAPILLIPES, *Boiss. Voy. Bot. Esp.* p. 98, t. 27 B (1839); *Willk. et Lange, Prodr. Fl. Hisp.* iii. p. 621.

Hab. Sierra Bermeja, in Andalusia, up to 1200 metres.

Iconogr.—*Boiss. l. c.*

28. A. OXYPETALA, *Sibth. et Sm. Fl. Græc. Prodr.* i. p. 303 (1806); *Boiss. Fl. Orient.* i. p. 704.

Geogr. limits.—*N. & W.* Greece: nome of Achaia.
S. & E. Syria: Mt. Lebanon, at Aïn-Sofa.

Iconogr.—*Sibth. & Sm. Fl. Græca,* v. p. 26, t. 437.

Boissier evidently misunderstood this figure of the plant, as he writes after his description of a new species, *A. Rhodia,*—"an eadem sit ac *A. oxypetala* e miserrimis hujus operis diagnosibus absque iconis inspectione dignoscere nequeo."

29. A. PAMPHYLICA, *Boiss. & Heldr. Diagn. Pl. Or. nov.* Ser. I. viii. p. 102 (1849); *Boiss. Fl. Orient* i. p. 704.

Tenera, pumila, patule hirtella, 7–15 centim. Caulis erectus, stricte et dichotome ramosus fere eglandulosus, superne laxe corymbosus, pauciflorus. Folia inferiora ovata vel deltoidea obtusa in petiolum brevem contracta, superiora elliptico-linearia acuta; pedicelli erecti setacei. Sepala lanceolata acuminata obsolete 5-nervia, late membranaceo-marginata. Petala obovata obtusa inferne longe attenuata, calyce $\frac{1}{3}$ longiora. Styli supra medium hirtello-papillosi. Capsula inclusa. Semina reniformia granulato-tuberculata.

A. modestæ hæc planta notis fere omnibus est simillima, diversa tamen est habenda ob inflorescentiam puberulam non glanduloso-pilosam et petala obovata non elliptico-oblonga; item ob folia caulina omnia plus vel minus ovata vel spathulato-elliptica non vero pleraque linearia.

β. lycia, *Boiss. Fl. Orient., Suppl.* p. 116 (1888).

Capsula calycem excedens. Planta magis nana.

Geogr. limits.—Asia Minor.

N. Amphitheatre of the town of Perge, in prov. of Anatolia.

S. Cyprus. *E.* Genova, in prov. of Cilicia.

W. Castelrosso, on the coast of prov. of Anatolia (var. β).

30. A. SABULINEA, *Griseb. in Russegg. Reise,* ii. p. 333 (1843); *Boiss. Fl. Orient.* i. p. 704.

Facies *A. controversæ* et *A. modestæ*, a præcedentibus foliorum formâ diversa.

Geogr. area. Turkey in Asia: in the provinces of Diarbekir and Orfah.

31. A. ALGARBIENSIS, *Welw. ined. in pl. exsicc.* (1851), ap. *Willk. Ic. descr. Pl. Nov. Hisp.* i. p. 91, t. 61 D (1853); *Walp. Ann. Bot.* iv. p. 255.

Gracillima, 3–7 centim. Caulis a basi ramosus; rami erecti simplices cauliformes teretes purpurascentes, inferne glabri, mediatim puberuli, superne viscidi, patentim glanduloso-pubescentes. Folia minima glabra, margine ciliolata, lanceolata obtusa integerrima, nervo mediano valido purpurascente percursa, venis lateralibus obsoletis, patulo-erecta. Flores in dichasium dispositi; cymæ dichotomæ depauperatæ compositè sed laxius racemosæ; flores longissime pedunculati; pedicelli flexuosi capillares; bracteæ lanceolato-lineares obtusæ herbaceæ glanduloso-ciliatæ. Sepala patentia lanceolata acuta anguste membranaceo-marginata, 5-nervia, dorso ad nervos et margine dense glanduloso-pubescentia. Petala obovato-cuneata emarginata, calyce duplo longiora, utroque dimidio triangulari. Antheræ flavæ. Semina reniformi-compressa ruguloso-tuberculata.

Hab. S. Portugal: prov. of Algarve.

Iconogr.—*Willk. l. c.*

32. A. LIEBMANNIANA, *Rohrb. in Linnæa,* xxxvii. (1871), p. 274; *Jacks. Ind. Kew.* i. p. 180.

Glauca. Caules adscendentes simplices graciles piloso-puberuli, 3–8 centim. Folia minima, lanceolata vel ovato-lanceolata mucronulato-acuminata, ad basin versus attenuata, margine ciliata, utrinque punctulato-scabrida. Flores solitarii vel in dichasium pauciflorum dispositi, longe pedicellati, pedicellis tenuibus. Sepala ovato-lanceolata mucronulato-acuminata

viridia punctulato-scabra, margine ad basin ciliata late scariosa Petala alba ovato-oblonga obtusa, calycem superantia. Semina atra seriatim punctulata.

Hæc species inter Caryophyllaceas Mexicanas Liebmannianas sub *no.* 77 reperitur, nullus autem locus natalis in schedulâ propositus est. Itaque an hæc herba revera sit civis Mexicana adhuc est dubium.

Hab. Republic of Brazil.

†† Folia uninervia. Sepala apice incurva obtusa.

33. A. Loscosii, *Texid. in Losc. Trat. Pl. Aragon*, ii. p. 28 (1877); *Willk. Prodr. Fl. Hisp., Supplem.* p. 276 (1893).

Glanduloso-pubescens, cinereo-virens, viscida. Caules a basi dichotomo-ramosi. Folia oblongo-lanceolata vel oblongo-linearia acuta, basi attenuata utrinque fimbriato-ciliata. Cymæ dichasiiformes terminales laxissimæ; flores stricte pedicellati, pedicellis sub anthesi erectis, postea patentibus. Sepala oblonga navicularia, anguste membranaceo-marginata, dorso margineque fimbriis articulatis acutis obsita. Petala alba obovata, calyce duplo longiora. Antheræ atro-purpureæ. Capsula ovoideo-conica. Semina reniformia, acute tuberculata.

Geogr. area.—E. Spain.

N. Monserrat in Catalonia (*Tremols*, Pl. exs. Cat.).

E. Monistrol in Catalonia (*Vayr.* Pl. Not. Cat.).

S. & W. Serrania de Cuença in New Castile (*Diek*, 1892).

Iconogr.—*Willk. Illustr. Fl. Hisp.* i. (1883) t. 62 B.

Syn. *A. modesta*, var. *Assoana*, Losc. et Pard. (*ex parte*).

34. A. ciliaris, *Losc. Trat. Pl. Aragon*, i. p. 69 (1876); *Willk. Prodr. Fl. Hisp., Supplem.* p. 276 (1893).

Gracilis, pulverulento-puberula. Caules sæpe a basi ramosi violascentes, ramis dichotomis. Folia oblongo-linearia, basi attenuata, fimbriato-ciliata, fimbriis articulatis obtusis albis. Cymæ dichasiiformes terminales laxissimæ; bracteæ ad basin fimbriatæ; pedicelli erecti. Sepala oblonga navicularia, late membranaceo-marginata, exteriora 3 a basi ad medium fimbriata. Petala alba obovato-elliptica, calyce duplo longiora. Antheræ roseo-purpurascentes. Capsula globoso-conica. Semina reniformia, obtuse tuberculata.

Hab. Aragon and New Castile.

N. S. Aragon: Peña Palomera (*Arenaria* no. 382 ex *Asso*, Syn. Stirp. Aragon. [1779]).
S. New Castile: valley of river Cabriel (*Mme. Blanca de Catalan*, 1879).
E. S.E. Aragon: Cantavieja (*Loscos*, 1876).
W. Aragon: Albarracin (*Rev. Padre Zapater*, 1879).

Iconogr.—*Willk. Illustr. Fl. Hisp.* i. p. 96, t. 62 A (1883).

Syn. *A. modesta*, var. *Assoana*, Losc. et Pard. (*ex parte*).

††† Folia plurinervia. Sepala apice recta acuta.

35. A. conferta, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 51 (1842); *Fl. Orient.* i. p. 702.

Velutino-cinerascens, pumila. Caules 5–13 centim., foliosi purpurascentes, apice 1–3 fasciculos confertifloros ferentes, numerosi. Folia parva ovata acuta 5–7-nervia. Pedicelli stricti hispidi. Sepala lanceolata carinato-trinervia hispida anguste membranaceo-marginata. Petala ovata obtusa. Semina reniformi-globosa tuberculata.—Annua vel biennis.

Described from Prof. Haussknecht's specimens from Mt. Pindus.

Hab. Turkey: Mt. Olympus in Macedonia, Mt. Zygos in Epirus (*Haussknecht*, in Mittheil. Thüring. Bot. Ver. 1893, p. 57); Mt. Cika near Delvino in Albania (*Baldacci*, in Bull. Herb. Boiss. 1896, p. 619).

β. Species perennes.

† Flores solitarii, vel rarius cymis paucifloris (vulgo trifloris).

36. A. incrassata, *Lange, Pl. Nov. Hisp.* fasc. i. p. 3, t. 4. f. 2 (1864); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 624.

Laxe cæspitosa, dense hirtella. Caules numerosi diffusi prostrati adscendentes fragillimi tetragoni. Folia elliptica vel elliptico-lanceolata subglanduloso-hispida, margine valde cartilagineo-incrassata, rigida, cuspidato-acuminata, nervo mediano subtus valde prominulo excurrente, basi angustata barbato-ciliata, plerumque decussato-imbricata. Cymæ plerumque trifloræ; pedicellis hirtellis. Sepala ovata cuspidata membranaceo-marginata. Petala obovato-spathulata, calyce vix duplo longiora. Capsula 6-dentata. Semina reniformia granulata.

β. glabrescens, *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 624. Folia caulina basi ciliolatâ exceptâ utrinque glaberrima, surcu

lorum sterilium laxius disposita, vix imbricata, omnia tenuiora margine minus incrassata.

Geogr. area. N. & Central Spain, and Majorca in the Balearic Isles.

Iconogr.—*Lange, Pf. Nov. Hisp.* fasc. i. t. 4. f. 2.

SYN. *A. Bourgæana*, Coss. *ex* Willk. in Linnæa, 1876, p. 117 (var. β).

37. A. RACEMOSA, *Willk. in Bot. Zeit.* v. p. 239 (1847); *Prodr. Fl. Hisp.* iii. p. 627.

Specimens labelled *A. hispida*, Linn., in Salzmann's herbarium, stated to be found at Trapani in Sicily, were described by Presl under the name of *A. Salzmanni.* The description appears rather to tally with that of *A. racemosa*, but E. Tanfani states that no plant answering this description has since been found or recorded in the district; so that the matter remains in doubt for the present. The specimens on which the species is founded were collected by Cabrera "in montibus Bæticæ," and are labelled *Arenaria saxatilis* in Hänseler's herbarium. Similar specimens were collected by Perez Lara at Grazalema in Andalusia, and this is the only precise locality known for the plant.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* i. p. 97, t. 65 c.

38. A. ERINACEA, *Boiss. Voy. Bot. Espagne*, ii. p. 103, t. 29 A; *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 627.

Hab. Sierra de Leon, in Leon; Sierra de las Nieves, Sierra de Lujar, and Sierra Tejeda up to 2000 metres, in Andalusia.

Iconogr.—*Boiss. l. c.*

SYN. *A. aggregata* (*non* Loisel), Boiss. El. Plant. p. 23 (1838).

39. A. TETRAQUETRA, *Boiss. Voy. Bot. Espagne*, ii. p. 103, t. 29 B (1839–45); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 627.

Basi suffruticosa, cæspites compactos depressos glauco-virentes formans, nana. Folia minima connato-vaginantia recurva ovata canaliculata carinata, apice rotundata, margine incrassata, basi ciliolata, ceterùm glabra. Flores terminales solitarii sessiles, foliis supremis bracteiformibus calyce brevius stipati. Sepala oblongo-lanceolata obtusa ciliolata, dorso nervoso-striata. Petala spathulato-lanceolata alba, calycem superantia. Capsula dentibus 6 dehiscens. Semina tuberculata.

It would be absurd to cite Linnæus as the authority for this species. I would refer the pedantic purist, in the matter of

such specific names, to what Mr. Ball says in his remarks on *Cerastium glomeratum*, Thuill., in the course of his paper on the Flora of the Peruvian Andes. He writes: "It is, I think, time for botanists to free themselves from the servitude of adhering to a Linnean name when the object to which the name properly belongs is involved in confusion, and the practice serves only to prolong profitless controversy. Every one knows what is meant by *Cerastium glomeratum*, Thuill., but who is quite sure as to *Cerastium vulgatum*, Linn.?"

α. granatensis, *Boiss. Elench. Pl.* no. 34 (1840).
Hermaphrodita, floribus pentameris.

β. pyrenaïca, *Boiss. Elench. Pl.* no. 34 (1840).
Forma 1, legitima, *Gren. et Godr. Fl. de France*, i. p. 262. 3–6 centim., polygama, floribus pentameris.
Forma 2, condensata, *Gren. et Godr.*
Minor, polygama, floribus tetrameris, caulibusque abbreviatis.

Geogr. limits.—The Pyrenees (both French and Spanish sides), and Sierra Nevada in Andalusia, up to 3330 metres.

Iconogr.—*Boiss. Voy. Bot. Espagne*, ii. t. 293; drawing in Herb. Kew. by Prêtre (1824).

SYN. *A. amabilis*, Bory, in Ann. Gén. Sc. Nat. Phys. iii. p. 5 (1820).
A. decussata, Salisb. Prodr. p. 299.
A. imbricata (*non* Bieb.), Lag. Prodr. in Anal. Cienc. Nat. v. p. 278 (1802).

40. A. GRAVEOLENS, *Schreb. in Nov. Act. Nat. Curios.* iii. p. 478 (1767); *Boiss. Fl. Orient.* i. p. 700.

β. grandiflora, *Boiss. Fl. Orient.* i. p. 701.
Habitu notabiliter laxa; petala calyce duplo longiora.

γ. glabrescens, *Boiss. Fl. Orient.* i. p. 701.
Folia minus pubescentia. Sepala glabra tuberculata.

Hab. Anatolia: Mt. Manissa-dagh (on vertical precipitous cliffs) between Smyrna and Manissa (Magnesia).

Post (*Fl. Syr.*) mentions a var. *minuta*, but the plant does not seem to differ from the type, except in the somewhat smaller flowers. The forms which are recorded from Greece and Rumelia, and which are narrow-leaved, should be referred to *A. filicaulis*.

Geogr. limits.—*N.* Island of Scio, in the Turkish Archipelago.
S. Mt. Sinaï (*A. deflexa*, Decne. in Ann. Sc. Nat. 1835, p. 277).
E. Zebedâni, in the Anti-Lebanon.
W. Island of Crete.

Syn. *A. deflexa*, Decne. l. c.

A. muralis, Sieb. pl. exs. *ex* Spreng. Syst. Veg. ii. p. 397 (1825).

A. papillosa, Steud. Nomencl. ed. 2, i. p. 126.

A. pubescens, Urv. in Mém. Soc. Linn. Par. i. p. 306 (1822).

A. rhodia, Boiss. Diagn. Pl. Nov. Or., Ser. I. i. p. 52.

A. sipylea, Boiss. l. c. p. 51.

41. A. filicaulis, *Fenzl, in Griseb. Spicil. Fl. Rumel. Bithyn.* i. p. 203 (1843).

α. rumelica, *Williams.*

Syn. *A. graveolens*, var. *Athoa*, Boiss. Fl. Orient. i. p. 701.

A. graveolens, var. *nervosa*, Hal. & Charrel, in Oesterr. Bot. Zeit. 1892, p. 272.

Folia perparva lanceolata. Sepala subtrinervia. Capsula calyce sublongior.

Hab Mt. Athos, in Rumelia; also Mt. Pournar-dagh.

β. græca, *Williams.*

Syn. *A. graveolens*, var. *græca*, Boiss. Fl. Orient. i. p. 701.

Folia majora angustiora præ longitudine. Sepala ovato-oblonga tenuiter striato-5-nervia. Capsula inclusa.

Hab. Greece, Crete, and Anatolia.

Though this species is united with the preceding by Boissier and others, I think that the narrow-leaved forms should be separated from the broad-leaved forms, as they differ materially in other respects.

Geogr. limits.—S. Crete.

N. & E. Mt. Kapu-dagh, on the north coast of prov. of Anatolia (*Sintenis*, It. Trojanum, 1883, no. 502).

W. Khelmos, in the nome of Achaia, Greece.

†† Flores glomerato-capitati.

42. A. Armeriastrum, *Boiss. Elench. Pl. Hisp.* p. 22, n. 35 (1838); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 625, *Supplem.* p. 277.

α. elongata, *Boiss. Elench. Pl. Hisp.* p. 22.

Laxe cæspitosa. Caules filiformes erecti, 10–20 centim. Folia propter internodia elongata iis multò breviora, surculorum sterilium elongatorum laxe aut vix imbricata. Sepala valde nervosa.

β. frigida, *Boiss. Elench. Pl. Hisp.* p. 22.

Dense cæspitosa, surculis abbreviatis. Folia surculorum dense

imbricata. Capitula subsessilia pauciflora, vel flores subsolitarii. Sepala subenervia glabrescentia.

γ. cæsia, *Boiss. Elench. Pl. Hisp.* p. 22.

Laxe cæspitosa, tota pubescentia crispula densa cæsio-pruinosa. Caules elongati. Capitula pedunculata. Sepala stricta valde nervoso-striata sublanata.

Geogr. limits.—N. Murcia : Sierra d'el Mugrón (*Porta et Rigo*, exs. 1890).

S. & W. Andalusia : Sierra de Ronda (*Rouy*, 1881).

E. Valencia : Sierra Mariola (*Leresche*, 1881).

All three of these stations are an extension of the range of the species as given by Willkomm and Lange in 1878.

Iconogr.—*Boiss. Voy. Bot. Esp.* p. 102, t. 30.

43. A. CAPITATA, *Lam. Fl. Franç.* iii. p. 39 (1778); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 626.

β. querioides, *Willk. in Bot. Zeit.* v. p. 239 (1847).

Dense retrorsum tomentosa, canescens. Folia latiora, caulina superiora cordato-ovata, subrevoluta glabra.

This is the species described under *Saponaria* no. 5 in Linn. Hort. Upsal. p. 107, which had previously been figured by Magnol in 'Hortus Regius Monspeliensis,' p. 53, t. 5 (1697), from specimens gathered in the Cevennes mountains. Nyman (Consp. p. 116) erroneously quotes *A. aggregata*, Lamk., instead *A. capitata*. It has been pointed out above how it is impossible to keep up the species usually cited as *A. tetraquetra*, Linn.

Geogr. limits.—N. Piedmont : Col di Tenda in the Maritime Alps (*Gypsophila aggregata*, Linn.).

E. Liguria : Mt. Carmo in the Maritime Alps (*Gentili* ap. *Tanfani*).

S. Prov. of Murcia; Sierra de Alcaraz (the specimens figured by Barrelier).

W. N. Portugal (*ex* Nym. Consp. Fl. Eur., *A. tetraquetra*, Brot.).

Iconogr.—*Barrel. Pl. Gall. Hisp. Ital.* 595 (1714) (Rubeola montana); *All. Fl. Pedem.* t. 89. f. 1 (1785); *Gay in Ann. Sc. Nat. Bot.* iv. t. 4 (1828); *Reichb. Ic. Fl. Germ. Helv.* 4952 (Plinthine aggregata); drawing in Herb. Kew. by Prêtre, 1824 (A. tetraquetra *var.* aggregata).

SYN. *A. aggregata*, Loisel. Fl. Gall. i. p. 317.

A. Allionii, Raüsch. Nomencl. ed. 3, p. 130.

A. querioides, Pourr. *ex* Willk. in Bot. Zeit. v. p. 239 (1847).

A. tetraquetra, All. Fl. Pedem. ii. p. 115.
A. tetraquetra var. *aggregata*, Reichb. Syst. Plant. ii. p. 359.
Gypsophila aggregata, Linn. Sp. Plant. p. 406.
Plinthine aggregata, Reichb. Ic. Fl. Germ. Helv. 4952.
Rubeola montana, Barrel. Pl. Gall. Hisp. Ital. 595.
Stellaria muralis, Link, Enum. Hort. Berolin. i. p. 429.

44. A. PSEUDARMERIASTRUM, *Rouy, Exc. Bot. in Bull. Soc. Bot. France*, xxix. p. 46 (1882); *Willk. Prodr. Fl. Hisp.*, *Supplem.* p. 277.

Fruticulosa, glauca. Caules 25–50 centim., elongati numerosi teretes graciles intricati fere filiformes, adscendentes vel erecti pruinoso-puberuli. Folia brevia coriacea, basi vaginantia connata lineari-subulata cuspidata patula, supra canaliculata glabra, subtus convexo-carinata puberula, nervo calloso valido margine incrassato-cincta. Flores in capitula densa congesti; bracteæ ovali-lanceolatæ mucronatæ, margine ciliatæ, dorso nervoso-striatæ puberulæ, cum summis foliis involucratæ. Sepala elongato-lanceolata subulato-acutata nervoso-marginata, dorso nervoso-striata puberula. Petala spathalata, calycem æquantia. Antheræ albidæ. Capsula valvis 6 dehiscens. Semina tuberculata.

Distinguished from the preceding by its glomerules of flowers half the size, petals equalling the sepals, leaves shorter and less recurved, and the flowering-stems numerous and intricate.

Hab. Spain: Valldigna, in prov. of Valencia (*Rouy*, 1880).

b. Petala calyce breviora.

a. Species annuæ vel biennes (*i. e.* monotocæ).

† Flores cymosi, in ramulis interdum depauperati ad florem unicum reducti.

45. A. SERPYLLIFOLIA, *Linn. Sp. Plant.* p. 423 (1753); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 620.

aa. Eglandulosæ. Pedicelli calyce 2–3-plo longiores.

α. scabra, *Ledeb. Fl. Rossica*, i. p. 369 (1842).

Glauca, totâ pube minutissimâ scabrâ. Pedicelli fructiferi erecti.

β. alpina, *Gaud. Fl. Helvetica*, iii. p. 192 (1830).

Planta humilior, viridis vel flavicans, pubescentia longiore. Flores in paniculam densam dispositi. Sepala longius acuminata,

interiora angustius membranaceo-marginata. Capsula oblongo-ovoidea, minus ventricosa.

bb. Eglandulosæ. Pedicelli calycem subæquantes, vel eo tantum sesquilongiores.

γ. macrocarpa, *Lloyd, Fl. Loire-Inf.* p. 42 (1844).

Viridis, scabra. Caules 2–10 centim. Panicula densa, brevis; pedicellis fructiferis erectis, calycem æquantibus. Sepala nervis densatis instructa. Capsula quam in typo lentior.

δ. gracillima, *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 620.

Pusilla, tenera. Caules 2–10 centim., ob internodia abbreviata eleganter distichophylla. Folia minima sed internodia superantia. Flores dimidio minores quam in var. *a*, in cymam subcorymbosam dispositi. Sepala interiora subuninervia (nervis lateralibus fere obsoletis). Semina dimidio minora.

cc. Glanduloso-pilosæ. Pedicelli calyce 2–3-plo longiores.

ε. patula, *Martr.-Don.* (sp.) *Fl. Tarn,* i. p. 107 (1864).

Viridis. Rami diffuso-patentes. Pedicelli fructiferi repando-patentes.

ζ. alpicola, *G. Beck, in Ann. k.-k. Naturhist. Hofmus.* vi. p. 326 (1891).

Tota copiose glanduloso-pilosa; planta ramosissima multiflora procumbens. Sepala ovata acuminata multinervia viridia, interiora membranaceo-marginata. Petala elliptica, calyce tertia breviora. Semina squamato-verrucosa.

dd. Glandulosæ. Pedicelli calyce sesquilongiores.

η. viscidula, *Roth, Enum. Pl. Germ.* ii. p. 318 (1827).

Minor, glauca, superne tantum glanduloso-pilosa. Pedicelli erecti. Capsula latior, fere subglobulosa.

Hæc herba verùm est species polymorpha, quoad internodiorum longitudinem, foliorum figuram, florum magnitudinem et dispositionem atque indumentum valde varians.

As in the case of *A. grandiflora*, the grouping (and sequence) of the many variable forms of this species into seven varieties is based on examination of the very copious material in the Vienna Herbarium. It is a common plant of wide distribution over Europe, Asia, and North Africa; introduced into North America, but scarcely naturalized there.

On English hills it ascends to 600 metres; on the Great

St. Bernard in the Swiss Canton of Valais it occurs at 2450 metres, and near Bergamasco in Piedmont it reaches 2500 metres in the Caucasus it is found up to 1830 metres. In geographical range the species does not extend so far beyond the Arctic Circle as *A. ciliata*.

Geogr. limits.—*N.* Norway, lat. 69° (*Norman*). *S.* Socotra.
E. China: by the stream Tchin-teou-yn near Tali, in prov. of Yun-nan (*Delavay*, 1884, no. 910, ex *Franch.* in Bull. Soc. Bot. France, xxxiii. p. 429 (1886)).
W. Ireland: county of Mayo.

Iconogr.—Var. *α*, *Fuchs*, *Hist. Stirp. Comm.* (1542), p. 20, t. 23 (under the name of *Alsine minor*,—the earliest notice and figure of a plant of *Arenaria*); *Engl. Bot.*, (ed. 1) t. 923, (ed. 2) t. 642, (ed. 3) t. 235; *Fl. Danica*, t. 977; *Tenore*, *Fl. Napol.* iv. p. 222, t. 228. fig. 3 (A. sphærocarpa); *Reichb. Ic. Fl. Germ. Helv.* 4941; *Willk. Ic. descr. Pl. Rar. Hisp.* i. t. 63 C; *Curt. Fl. Lond.* ii. t. 51; *Schkuhr*, *Bot. Handb.* t. 122.

Var. *γ*, *Willk. Ic. descr. Pl. Rar. Hisp.* i. t. 63 A, p. 95.

Var. *δ*, *Willk. l. c.* t. 63 B.

SYN. *Arenaria breviflora*, Gilib. Fl. Lituan. ii. p. 155.
A. cantabrica, Amo, Fl. Iber. vi. p. 140 (*var. δ*).
A. Lloydii, Jord. Pugill. p. 37 (*var. γ*).
A. Marschlinsii, Koch, in Flora, 1841, ii. p. 509 (*var. β*).
A. sphærocarpa, Martr. Fl. Tarn, p. 107 (*non* Ten.) (*var. ε*).
A. sphærocarpa, Ten. Viagg. Bot. Abruzz. p. 66 (1832) (*var. a*).
A. uralensis, Pall. *ex* Spreng. Syst. Veg. ii. p. 396 (*var. η*).
A. varia, Dulac, Fl. Hautes-Pyr. p. 249.
A. viscida, Hall. f. *ex* Loisel. Not. Pl. p. 68 (*var. η*).
A. Wallichiana, Ser. in Cand. Prodr. i. p. 411.
Alsine serpyllifolia, Crantz, Instit. ii. p. 406.
Alsinella serpyllifolia, S. F. Gray, Nat. Arr. Pl. ii. p. 665.
Alsinanthus serpyllifolius, Desv. Journ. Bot. 1814.
Euthalia serpyllifolia, Rupr. Fl. Caucasi, p. 220.
Stellaria serpyllifolia, Scop. Fl. Carn. (ed. 2) i. p. 319.

46. A. LEPTOCLADOS, *Guss. Fl. Sic. Syn.* p. 284 (1845); *Willk. & Lange*, *Prodr. Fl. Hisp.* iii. p. 620.

a. scabra, *Rouy & Fouc. Fl. de France*, iii. p. 242 (1896).
Pubescenti-scabra, eglandulosa. Panicula fere laxa, floribus parvis.

β. viscidula, *Rouy et Fouc. Fl. de France*, iii. p. 242 (1896).

Glanduloso-pubescens. Panicula minus laxa, floribus parvis.

γ. minutiflora, *Losc.* (sp.) *Tratad. Pl. Aragon*, i. p. 21 (1876).

Dense glanduloso-puberula ideoque subcinerea. Ramosissima diffusa floribunda, floribus autem perparvis.

Ab *A. serpyllifolia* hæc varietas (γ) cui similis, differt floribus 3–4-plove minoribus oculo nudo vix perspicuis, sepalis acuminato-subulatis, inæqualibus, capsulâ longioribus; petalis calyce dimidio brevioribus, capsulâ triplo minore, ovoidea basi non ventricosa, membranacea, inter digitos compressibili et facillime rumpente, seminibus duplo minoribus, dorso tuberculis acuminatis hispidulis.—Primo intuitu discernitur copiosa pubescentia glutinosa, caulibus intricato-ramosissimis flexibilibus, foliis parvis mollibus submembranaceis, pellucido-punctatis, floribus perparvis: planta erectiuscula vel diffusa, usque ad 20 centim et ultra.

δ. crassifolia, *Freyn, Fl. Süd. Istr.* p. 252 (1877–78); *Marchesetti, Fl. Trieste*, p. 72 (1896–97).

Caules magis fragiles, glandulosi. Folia crassa. Pedicelli abbreviati.

Mr. François Crépin has observed that this plant, growing in similar localities to those where *A. serpyllifolia* is found, seems quite distinct, and that its characters are fixed and constant. Maximowicz says that this species is the more common of the two in Siberia, though the plant is usually recorded under the name of *A. serpyllifolia*. In Japan it is the only representative of the genus recorded up to the present. Mr. R. Yatabe's specimens of *A. platysperma* belong to *Moehringia*.

Geogr. limits.—*N.* Siberia (*Maximowicz*). *S.* Algeria.
E. Japan (*Franchet*). *W.* Ireland (Galway).

Iconogr.—*Reichb. Ic. Fl. Germ. Helv.* 4941 β; *Sô mokou Zoussetz*, viii. p. 68 (O. Wakobe).

Syn. *A. grandiflora* (*non* Linn.), Tornab. Fl. Sic. p. 151, et Fl. Aetnea, p. 169.
A. serpyllifolia, Guss. Fl. Sic. Syn. i. p. 495.
Alsine leptoclados, Calc. Desc. Is. Lin. p. 22.

47. A. cassia, *Boiss. Diagn. Pl. Or. nov.* Ser. I. viii. p. 101 (1849); *F Orient.* i. p. 702.

Pubescenti-scabra. Caules decumbentes dichotome paniculato-ramosi. Folia ovato-spathulata obtusa mucronulata subsessilia plurinervia tuberculato-punctata. Flores in dichasium dispositi;

pedicelli erecti, calyce duplo longiores. Sepala late ovata scabrido hirsuta, exteriora 5-nervia, interiora et intermedium 3-nervia. Petala oblonga, calyce triplo breviora. Capsula ventricosa ovata, in collum exsertum abrupte attenuata. Semina reniformia, tuberculata.

A. serpyllifoliæ affinis, differt caulibus brevioribus decumbentibus, foliis obtusioribus, sepalis latioribus plurinerviis, capsulâ duplo majori (5 mm. long.) in collum attenuatâ, seminibus triplo majoribus. Culta in Horto Boissieriano characteres servavit.

Hab. N. Syria: the wooded heights of Mt. Cassius and the cedar region of Mt. Lebanon.

48. A. NEVADENSIS, *Boiss. Diagn. Pl. Or. nov.* Ser. II. i. p. 90 (1854); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 619.

Annua, humilis, obscure virens, tota calyce excepto viscido-puberula. Radix prælonga obliqua cylindrica. Caulis 5–8 centim., erectus robustus, e nodis inferioribus approximatis ramos patulos strictos robustos cauliformes teretes edens. Folia subtrinervia; inferiora patula ovata in petiolum brevem subvaginantem attenuata, obtusa, sæpe amœne purpurascentia; cetera adpressa lineari-lanceolata minus obtusa sessilia canaliculata. Flores inconspicui, ad apicem ramorum conferti corymboso-cymosi; pedicelli erecti; bracteæ lineares uninerviæ omnino herbaceæ. Sepala lanceolata obtusa membranaceo-marginata ciliolata, dorso nervoso-striata. Petala alba oblonga obtusa, calyce triplo breviora. Capsula ovato-oblonga, dentibus 6 dehiscens. Semina reniformia, transverse ruguloso-tuberculata.

Hab. Andalusia: the peak of Mulahacen on Sierra Nevada.

Iconogr.—*Willk. Ic. descr. Pl. Rar. Hisp.* p. 94, t. 62 D.

49. A. TREMULA, *Boiss. Diagn. Pl. Or. nov.* Ser. I. viii. p. 101 (1849); *Fl. Orient.* i. p. 702.

Inferne pruinoso-scabridula, 15–22 centim. Caules 1–3, dichotome ramosi, effuse cymosi. Folia oblonga acuta subsessilia. Pedicelli rigidi capillares. Sepala ovato-oblonga acuminata 3-nervia glabra late membranaceo-marginata. Petala oblonga, calyce triplo breviora. Semina reniformi-globosa, ruguloso-tuberculata.

Planta facie *Lini cathartici*; capsulam magnam habet *A. serpyllifoliæ* a quâ differt inflorescentiâ valde effusâ, calyce glabro, et seminibus triplo majoribus.

Hab. On the wooded heights of Mt. Cassius in N. Syria, and in the gorge of Guzuldere on the coast of Cilicia.

50. A. MACROSEPALA, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 52 (1842); *Fl. Orient.* i. p. 703.

β. minor, *Boiss. Fl. Orient.* i. p. 703.

Planta minor, cymis magis confertis. Calyx tantùm 4 mm. longus. Petala calyce triplo minora.

Planta facie *Saponariam viscosam* revocat, cujus flores eis *A. serpyllifoliæ* triplo majores.

Mr. Ball's specimens considerably extend the range of this species.

Geogr. limits.—*N.* Anatolia, between Karaghieulderé and Ushak.

W. (var. *β*). Anatolia, betwen Ushak and Yachamichlarkeui.

S. & E. Mt. Lebanon, in Syria (*Ball*, It. Orientale, 1877, no. 1683, no. 1997).

SYN. *A. saponarioides*, Boiss. & Bal. Diagn. Pl. Or. nov. Ser. II. vi. p. 35 (var. *β*).

51. A. CONICA, *Boiss. Voy. Bot. Espagne*, ii. p. 98, t. 31 B (1839–45); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 621.

Specifically distinct in the form of the closed calyx, in which it differs further from *A. emarginata* in having acute sepals provided with three nerves ciliated on the dorsal surface.

Hab. Andalusia: Niebla and Malaga.

Iconogr.—*Boiss. l. c.*

52. A. ORBICULARIS, *Vis. Fl. Dalmatica*, iii. p. 180 (1850), et *Suppl.* p. 131, t. 5; *Nym. Consp. Fl. Eur.* p. 114.

Annua. Caules filiformes gracillimi puberuli subramosi, superne floridi nudi. Folia orbiculata mucronulata petiolata punctata tenuia piloso-ciliata venoso-reticulata, basi 3-nervia; floralia angusta linearia. Flores in dichasium gracile dispositi. Sepala æquilonga lineari-lanceolata acuminata 5-nervia; inter nervos transverse venulosa, interiora solum membranaceo-marginata. Petala oblongo-ovata. Capsula dentibus 6 obtusis dehiscens. Semina reniformia ruguloso-muricata.

Ab *A. rotundifolia* differt, pedicellis terminalibus nec lateralibus, divisionum loco foliis binis linearibus, nec orbicularibus ut reliquis plantæ foliis.

Hab. Mt. Velebith, in Dalmatia.

Iconogr.—*Vis. l. c.*

†† Flores subsessiles, capitato-congesti. Capsula ovata sulcata.

53. A. NANA, *Boiss. & Heldr. Diagn. Pl. Or. Nov.* Ser. I. viii. p. 103 (1849); *Boiss. Fl. Orient.* i. p. 703.

Annua; nana, glanduloso-hirta. Caules 1–3, tantum 21 mm. longi, erecti simplices. Folia ovato-oblonga obtusa 5–7-nervia. Cyma conferta 1–5-flora, foliis summis involucrata. Sepala oblonga acuta 3–5-nervia navicularia apice recta. Petala ovata, calyce 3-plo breviora. Semina granulata, reniformi-compressa.

Hab. Crete; also Cyprus (*Sintenis and Rigo*, It. Cyprium, 1880, no. 762).

††† Flores subsessiles, corymboso-fasciculati. Capsula anguste cylindrica.

54. A. GUICCIARDII, *Boiss. et Heldr. Diagn. Pl. Or. Nov.* Ser. II. v. p. 60 (1856); *Boiss. Fl. Orient.* i. p. 703.

Annua; pubescenti-scabra, pilis plerumque retrorsis, superne sæpe transversis. Caudex simplex vel a collo sæpius pluricaulis. Caules nani erecti simplices, tantùm 23 mm. longi. Folia ovato-oblonga acuta plurinervia, inferiora in petiolum attenuata, superiora sessilia angustiora, ciliata; bracteæ a foliis haud distinguendæ. Calyx angustus; sepala lanceolata acuminata scabra 3-nervia valde nervosa, apice recurva anguste scarioso-marginata. Petala oblonga, calyce 3-plo breviora. Capsula dentibus 6 obtusis dehiscens. Semina rugoso-tuberculata nigra, reniformia vix compressa, dorso plana vel leviter sulcata.

Ab *A. nana* præsertim differt, foliis acutis, sepalis apice acuminatis recurvis nec rectis; facies autem verum *Alsines*; ab omnibus speciebus sectionis *Euthaliæ* capsulâ anguste cylindricâ facile dignoscenda.

There is no specimen of this interesting and distinct species in Herb. Kew. or Herb. Mus. Brit.; so that the above description is drawn up from specimens kindly sent by Dr. Th. von Heldreich from his own herbarium, which were gathered in the *locus classicus*. At first glance the plant certainly more resembles an *Alsine*, but an examination of the capsule shows that it dehisces by six short equal teeth. In three capsules from different specimens there were respectively 7, 9, and 13 seeds. The capsules were firmly closed, so that I do not think that any had escaped. Prof. von Heldreich points out that the plant was discovered on Mt. Parnès in Attica by his old friend T. Guicciardi in 1854, and not by

himself as stated by Boissier. The species cannot be referred to the section *Porphyranthecæ*, which includes *A. purpurascens*, as the latter is a perennial plant with smooth shining leaves and flattened smooth seeds.

Geogr. area. Greece: nome of Attica, in the fir zone of Mt. Parnès near the summit at 1200–1350 metres (*Guicciardi*, 1854), and on Mt. Parnassus (*Guicciardi*, 1857); nome of Laconia, on Mt. Malevo, and near Zatuna on the mountains of the nome of Arcadia (*Orphanides*, 1870, from the last locality much larger and more robust specimens).

β. Species perennes. Flores cymosi.

55. A. OVALIFOLIA, *Somm. & Lev. Pl. Caucac. nov.*, in *Act. Hort. Petropol.* xiii. p. 40 (1893).

Radix tenuis. Caules permulti filiformes flaccidi prostrati undique proserpentes ramosissimi inferne radiculiferi, tenuiter puberuli; rami axillares vel terminales, elongati dichotome paniculati multiflori (20 florum et ultrà). Folia breviter petiolata uninervia glabra fere acuta ovata, petiolo hinc inde ciliis paucis consperso; bracteæ, præter supremas, foliaceæ. Sepala ovato-lanceolata acuta glabra 5-nervia, nervis lateralibus vix distinctis, anguste hyalino-marginata. Petala e basi cuneatâ ovato-lanceolata. Antheræ fusco-rubellæ. Semina nigra, globosa granulato-rugulosa.

Affinis *A. rotundifoliæ*, sed petalis quam calyce brevioribus. Ab ea etiam planta differt ramis multifloris elongatis, foliis ovatis nec orbiculatis plerumque subacutis, et bracteis omnibus præter supremas foliaceis: altit. 30 centim. et ultrà.

Hab. Abkhasia in Trans-Caucasia; at 1600 metres in valley of the R. Kliutsch.

Series B.—Stamina 5.

56. A. ANDINA, *Rohrb. in Linnæa*, xxxvii. p. 255 (1871–72); *Jacks. Ind. Kew.* i. p. 178.

Caules pusilli, cæspitem laxum formantes, plus minusve ramosi, ramis brevibus adscendentibus dense foliosis, glaberrimi, 3–5 centim. Folia valde approximata, crassiuscula lineari- vel sub-spathulato-lanceolata subaristata, ad basin membranaceam vix angustata, glaberrima. Flores solitarii terminales, brevissime pedicellati, pedicello glabro. Sepala ovato-oblonga obtusa flava.

Petala nulla. Capsula ovata, valvis 3 latis emarginato-bifidis dehiscens. Semina brunnea globuloso-reniformia, striatim granulata.

Species valde insignis, a plurimis meridionali-americanis diversa seminum structurâ.

Hab. Bolivia: prov. of Larecaja, at 3300 metres.

57. A. PENTANDRA, *Maxim. in Bull. Acad. Pétersb.* xxvi. p. 429 (1880); *Pl. Mongol.* p. 96, t. 6 (1889).

Suffrutex glaber, trunco crasso lignoso polycephalo, 30 centim. Folia subulata pungentia basi breviter membranacea, caulina connata margine scaberula. Cyma terminalis, ter trichotoma; bracteæ abbreviatæ lanceolatæ præter costam hyalinæ. Sepala lanceolata acuminata late hyalino-marginata, extima in alabastro breviora. Petala oblonga, calyce paullo longiora. Stamina 5, et staminodia 5. Ovarium ovatum, ovulis 2. Semina obtuse tuberculata.

Hab. Soungaria; not far from the Mongolian frontier, in the mountains of Kitschui-ne-tau near the post of Saissan (*Potanin*).

Iconogr.—*Maxim. l. c.*

Sectio ii. SIKKIMENSES.

Series A.—Stamina 10.

Subsectio 1.—Folia margine incrassata aut nervoso-marginata. Calyx basi rotundatus.

58. A. CILIOLATA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 240 (1874); *Duthie, List N. W. Ind. Pl.* p. 22 (1881).

Eglanduloso-pubescens, laxe cæspitosa. Caules 5–7 centim., simplices bilineato-pubescentes foliosi. Folia ovata vel oblonga, cuspidata vel acuminata, obscure uninervia, basi attenuata vix petiolata, utrinque puberula, margine pilis longis articulatis hispidis ciliato. Pedicelli villoso-pubescentes ebracteati. Sepala lanceolata acuta ciliata. Petala alba late obovata apice rotundata, calycem superantia. Capsula ovoideo-globosa.

β. pendula, *Duthie, Pl. of Kumaon*, no. 2761 (1884) in Herb. Kew.

Habitu laxior. Pedicelli recurvati.

Hab. Napalcha, in Byans.

Geogr. area. Sikkim Himalaya; also Kumaon and Garhwal (*Duthie*).

Subsectio 2.—Folia margine non incrassata neque nervoso-marginata. Calyx campanulatus.

α. Petala vix unguiculata.

59. A. STRACHEYI, *Edgew. in Hook. f. Fl. Brit. India*, i. p. 240 (1874); *Jacks. Ind. Kew.* i. p. 181.

Glaberrima. Caules 2–5 centim., adscendentes simplices. Folia anguste lineari-oblonga acuminata vel acuta, nervis obscuris, plana. Sepala lanceolata acuminata coriacea, apice recta. Petala albida obovata apice rotundata, calycem superantia.

Specifically distinct in being wholly glabrous.

Hab. W. Tibet, Rakas Tal at 4650 metres; and Ladakh in Kashmir; also N.W. Tibet at 5750 metres (*Capt. Deasy's* Exped. Tibet 1896–97, no. 876).

60. A. MELANDRYOIDES, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 241 (1874); *Jacks. Ind. Kew.* i. p. 180.

Glanduloso-pubescens. Caulis 5–10 centim., a basi ramosus; rami adscendentes cylindracei simplices vel parce ramosi, inferne glabri. Folia laxe disposita, sessilia carnosula, sordide viridescentia vel basin versus purpurascentia, utrinque glandulosa, oblongo-elliptica vel oblongo-lanceolata obtusa uninervia. Pedicelli primùm cernui, fructiferi multùm elongati stricti erecti, dense glandulosi. Calyx basi truncatus; sepala glandulosa angusta, apicibus recurva obtusa. Petala carnea vel roseo-purpurascentia, linearia apice rotundata, calycem superantia.

A well-marked species, resembling somewhat in habit *Cerastium trigynum*, very glandular, with flesh-coloured or purplish flowers.

Hab. Sikkim Himalaya, at 4200 to 5400 metres.

61. A. BULICA, *Stapf, ined. in Herb. Orientale, in Herb. Kew.*

Pumila, asperulo-pubescens. Caudex parce ramosus. Folia spathulata acuta, basin versus attenuata vix autem petiolata, margine scabra. Sepala lanceolata acuminata asperulo-ciliata late membranaceo-marginata. Petala ovato-lanceolata, apice vix acuta, basi vix unguiculata, sepalis fere bis longiora. Semina subreniformi-globosa.

Hab. Persia: Mt. Kuh-Bul (1885).

β. Petala in unguem attenuata.

62. A. Brotherana, *Trautv. in Act. Hort. Petropol.* viii. p. 151 (1883); *Boiss. Fl. Orient., Suppl.* p. 115 (1888).

Glaberrima, densissime cæspitosa, pulvinulos parvos exhibens 37 mm. Folia minuta, ovato-elliptica vel ovato-oblonga, obtusa ciliata 3-nervia, supra concava fere enervia, basin versus pectinatim ciliata. Flores sessiles cæspiti immersi. Sepala ovato-oblonga obtusa, basin versus ciliata, 3-nervia, nervis fere obsoletis, margine anguste albo-membranacea. Petala calycem longe superantia, lineari-oblonga integra, alba. Ovarium ovatum, profunde trisulcatum.

With regard to Trautvetter's description, in the specimens I examined the seeds were very minute, certainly not black, and did not appear to be smooth. I have therefore placed it in this section, rather than in the subgenus *Dicranilla*, after an examination of the dried specimens.

Plantula *Gypsophilæ aretioidi* vel *Alsinæ aretioidi* facie similis, pulvilli ramis arcte adpressis imbricatim et columnariter foliosis. Verùm herba quoad habitum *Thylacospermo rupifrago* simillima, quod autem reliquum est, ab hâc diversa: planta tota, exceptis foliis et sepalis ciliatis, glaberrima eglandulosa.

Hab. Trans-Caucasia: Mt. Mamisson, near the source of the R. Rion, in the Central Caucasus, in province of Imeretia, at 3000 metres (1877).

Series B.—Stamina 5, et staminodia 5.

63. A. nitida, *Rohrb. in Linnæa,* xxxvii. p. 249 (1871–72) (nomen); *Bartl. Reliq. Haenk.* ii. p. 12 (1825) (Cherleria nitida).

Cauliculi fragiles, basi procumbentes. Folia coriacea ovata mucronata, basi vix attenuata, connata glaberrima nitida plana, supra enervia, subtus bisulca, sulcis distantibus 4–7 mm. longis. Flores in cauliculorum summitate subterminales. Calyx cylindraceus glaberrimus coriaceus, basi turbinatus; sepala lanceolata acuta subcarinata, dorso non sulcata, apicibus recta non conniventia. Petala calyce duplo breviora, lineari-oblonga subacuta vel subemarginata, basi attenuata vix unguiculata. Capsula angusta. Semina fere globulosa, seriatim tuberculata.

Hab. Peru: Quebrada de l'Obrajillo.

Sectio iii. Leiospermæ.

Subsectio 1.—Flores solitarii, terminales et axillares.

64. A. muscoïdes, *H. B. & K., Nov. Gen. et Spec.* vi. p. 34, t. 26 (1823); *Jacks. Ind. Kew*, i. p. 180.

Hab. The Andes of Ecuador: summit of Mt. Antisana, at 4600 metres.

Iconogr.—*H. B. & K. l. c.*

If *A. nana*, Willd., were retained for the name of this species as Rohrbach suggests, a new name would have to be found for *A. nana*, Boiss., which would only cause confusion. Schlechtendal gave but a very meagre and unsatisfactory diagnosis of the plant in Willdenow's herbarium.

65. A. musciformis, *Triana & Planch. Prodr. Fl. Novo-Gran. in Ann. Sci. Nat.* sér. IV. xvii. 1862, p. 150; *Rohrb. in Linnæa*, xxxvii. (1871–72) p. 253.

Humilis, musciformis. Caules debiles, plus minus ramosi intricati glabri 4-sulcati, tantum 23–28 mm. alti. Folia parva approximata patentia neque unquam imbricata, lineari-lanceolata acuminata ac fere mucronulata, nervo medio subtus valde prominente, nervis 2 lateralibus fere obsoletis, ciliata. Pedicelli longi graciles villosuli. Sepala ovato-oblonga acuminata, margine scariosa ciliata. Petala alba oblongo-spathulata, calycem paullum excedentia. Semina lenticularia.

Differt hæc species a præcedenti, foliis non imbricatis eorumque nervo mediano prominente ciliatis neque enerviis glabris, floribus longe pedicellatis nec sessilibus, petalis calyce longioribus.

A. musciformis, Hook. f. in Fl. Brit. India, of Tibet, is a form of *A. polytrichoides*, and so becomes a synonym, apart from being homonymous with the South American plant.

Hab. Republic of Colombia: prov. of Pasto, Plateau de Tuquerres, at 3400 metres.

66. A. Halacsyi, *Bald. in Malpighia*, v. p. 65 (1891).

Cæspitosa, prostrata. Caudiculi tortuosi exiles plus minus longi, glabri vel parce pilosi præcipue juniores. Folia parvula in ramis sterilibus approximata, ovalia spathulata vel lanceolata carinato-uninervia, glandulosa vel sublævia, ad basin rigidula alata in petiolum attenuata. Rami 1–2-flori; pedicelli longi villosi nunquam glandulosi. Sepala foliacea oblongo-lanceolata obtusa

membranaceo-marginata utrinque glandulosa. Petala late spathulata, calycem paullum superantia. Capsula calyce paullo longior.

Hab. Albania.

67. A. Balansæ, *Boiss. Fl. Orient.* i. p. 700 (1867); *Fenzl, in Tchihat. Asie Min. Bot.* i. p. 237 (1860), (A. nilghirensis, varr. α et γ).

Caudiculi filiformes subterranei nudi, ramis procumbentibus dense foliosis. Folia obovata obtusa, basi attenuata, uninervia glabra vel scabro-hirsuta. Pedicelli breves stricti. Sepala glabra vel pilosula lanceolata acuta membranaceo-marginata obscure uninervia. Semina globoso-reniformia.

A formis *A. nilghirensis* longe distat, jamprimùm seminibus haud scabro-tuberculatis.

Hab. Turkey-in-Asia, Mt. Taurus in Cilicia; Persia, Mt. Kellal and Mt. Daëna; Beluchistan, Mt. Sebz.

Syn. *A. nilghirensis,* Fenzl, *ex* Boiss. Fl. Orient. i. p. 700.

Subsectio 2.—Flores solitarii axillares.

a. Sepala carinata, carinâ prominente pilosâ, margine ciliata, ceterùm glabra vel rarius puberula.

68. S. lanuginosa, *Rohrb. in Mart. Fl. Bras.* xiv. pt. ii. p. 274, t. 63 (1872); et *in Linnæa,* xxxvii. p. 259.

Caules diffusi, debiles, procumbentes, inferne teretes, superne sulcati vel subquadrangulares, ramosi, ramis oppositis aut altero minore vel abortivo; pubescentes, piiis brevibus plus minus densis subuncinato-reflexis, raro glabrescentes. Folia formâ et magnitudine variantia, nunc linearia et interdum subulata, nunc lineari-lanceolata lanceolatave, internodiis aut breviora aut rarius ea subæquantia, acutiuscula aut rarius obtusa, superiora sensim decrescentia, aut punctulata et ad nervos basinque tantum puberula aut plus minus scabriuscula. Pedicelli longi filiformes patentes dense puberuli, fructiferi apice sursum curvati. Sepala ovato-oblonga acuminata submucronata carinata, carinâ viridi pilis brevibus scabriusculâ, margine interdum ciliato late scariosa. Petala alba oblonga vel ovalia obtusa, plerumque calyce breviora vel interdum eum vix æquantia, rarò nulla. Stamina calyce paullum breviora. Ovarium subglobosum, in ipso flore jam per valvas dehiscens. Capsula ovato-oblonga. Semina sphæroideo-lenticularia.

Stirps magnopere variabilis, imprimis foliorum formâ et pubescentiâ, petalorum cum calyce proportione aliisque notis in lusus conversa, varietates tamen bene limitandas vix offert.

a. genuina, *Rohrb.*

Caules et folia nunc pubescentes nunc glabrescentes. Folia linearia vel lineari-lanceolata, plus minus acuminata, longitudine et latitudine ita variantia, ut his notis lusus vix distingui possint, 10–35 mm. lg., 2-8 mm. lt. Petala calyce breviora vel eum æquantia, interdum nulla.

Lusus 1:—Caules levissime puberuli vel interdum glabrescentes. Folia glabra punctulata, formâ valde variantia.

Lusus 2:—Caules levissime puberuli; folia nunc pilis brevissimis adspersa nunc punctulata glabrescentia.

Lusus 3:—Caulis et folia plus minus dense hirsuta.

β. diffusa, *Rohrb.*

Caules humifusi, valde diffusi, longe repentes, interdum adscendentes, glabrescentes vel pilis paucis adspersi. Folia parva, lineari-spathulata acuminata vel obtusa, pilis paucis adspersa vel punctulata, valde approximata, 5–8 mm. lg., 1–2 mm. lt., læte viridia. Petala calyce paullum breviora.

A species of very wide distribution in the New World. In the United States it extends from N. Carolina to Florida and westward to New Mexico. In Central America it is recorded in Costa Rica, and is common throughout Mexico from the province of Sonora in the north to the peninsula of Yucatan in the south. In the West Indies Bancroft and Wilson collected specimens in Jamaica, and Mr. Moseley brought specimens from Bermuda in the 'Challenger' Expedition. The species under one of its many forms is found in all the countries of S. America, excepting that there are no records for Guiana and Paraguay. Very few species of *Arenaria* extend south of the tropics. Besides *A. lanuginosa* they include only *A. tetragyna*, near Concepcion and on the summit of Pico de Pilque in the Andes of Chile, *A. palustris* in Chile and Argentina, and *A. serpens* var. *andicola* in the Chilean Andes. There are some very interesting (somewhat damaged) specimens in Herb. Kew. brought by Charles Darwin from Santa Cruz in Patagonia in the course of his voyage in H.M.S. 'Beagle' (1832–36). These historical specimens not only mark the south limit of the species, but, more important still, the limits of the southern range of the genus, which is thus fixed at 50° S. At first I thought they might be specimens of *A. palustris*, which is found in North Patagonia at Lake Nahuelhuapi on the Argentine side of the Andes; but the flowers are clearly axillary and not closer together towards the top of the stem as in the former species, and further the sepals

are shorter than the petals and hairy along the keel. Pinned to the sheet containing the specimens is a drawing by Sir J. D. Hooker of the magnified representation of a flower after fertilization, which well shows the structure of the gynæcium and the floral envelopes. In Haenke's herbarium are specimens collected in Chile; but whether they have been overlooked or not, the species is not included in Messrs. Reiche and Johow's recent 'Flora de Chile.'

Geogr. limits.—*N.* United States: San Antonio in New Mexico, 37° N. (*Whipple* Exped., and *Fendler*, no. 58).

S. Argentina: Santa Cruz in Patagonia, at the mouth of the river of that name (*Charles Darwin*).

W. Mexico: Santa Cruz in prov. of Sonora (*Wright*, no. 864).

E. Brazil: Caldas in prov. of Minas Geraës (*Lindberg*).

Iconogr.—*Rohrb. in Mart. Fl. Bras.* xiv. pt. II. t. 63.

SYN. *Arenaria alsinoides*, Willd. *ex* Schlecht. in Gesellsch. naturf. Fr. Berl. Mag. vii. p. 201 (1813).
A. diffusa, Ell. Sketch, i. p. 519.
A. Jussiæi, Cambess. in St.-Hil. Fl. Brasil. merid. ii. p. 126.
A. nemorosa, H. B. K. Nov. Gen. Spec. vi. p. 28.
A. paradoxa, Bartl. in Reliq. Haenk. ii. p. 15.
Alsine repens, Ruiz *ex* Rohrb. in Linnæa, xxxvii. p. 262.
Micropetalum lanuginosum, Pers. Syn. Plant. i. p. 509 (1805).
Mœhringia nemorosa, Fenzl *ex* Hemsl. Biol. Centr.-Amer., Bot. i. p. 69.
Spergulastrum lanuginosum, Michx. Fl. Bor.-Amer. i. p. 275.
Stellaria elongata, Nutt. Gen. i. p. 289.
S. lanuginosa, Torr. et Gray, Fl. Amer. Bor. i. p. 187.
S. longepedunculata, Baldw. *ex* Rohrb. in Linnæa, xxxvii. p. 261.
S. pubescens, H. B. K. Nov. Gen. Spec. vi. p. 28.
Bigelowia elongata, Rafin. in Journ. Phys. 1819, p. 289.

69. A. MEGALANTHA.—A. lanuginosa, *var.* megalantha, *Rohrb. in Linnæa*, xxxvii. p. 264 (1871-72).

Caules diffusi, laxi, primùm procumbentes, dein adscendenti-erectiusculi, inferne teretes, superne sulcati vel subquadrangulares, ramis oppositis aut altero minore vel rarius abortivo; pubescentes, pilis brevibus plus minus densis subuncinato-reflexis, vel glabrescentes. Folia formâ et magnitudine variantia, nunc anguste linearia subulataque, nunc lineari-lanceolata, nunc late ovata, internodiis aut breviora aut rarius ea subæquantia, mucronulato-acuminata, superiora sensim decrescentia, aut punctulata et ad nervos basinque tantum puberula aut plus minus

scabriuscula. Pedicelli filiformes patentes dense puberuli, fructiferi apice sursum curvati. Sepala ovato-oblonga acuminata carinata, carinâ viridi pilis brevibus scabriusculâ, margine interdum ciliato late scariosa. Petala alba oblonga obtusa, e calyce exserta. Ovarium subglobosum, in ipso flore jam per valvas dehiscens. Capsula ovato-oblonga. Semina sphæroideo-lenticularia.

Planta a præcedenti specifice distincta charactere cardinali petalorum longitudinis, ac in multis notis.

α. genuina, *Williams.*

SYN. *A. lanuginosa* var. δ. *megalantha*, Rohrb. in Linnæa, xxxvii. p. 264 (1871–72).

A. alsinoides var. *ovatifolia*, J. D. Smith in Bot. Gazette, 1893, p. 198.

Caules plus minus dense pubescentes vel glabrescentes. Folia late ovata, aut punctulata et margine tantum ciliata aut dense pubescentia, 8–12 mm. lg., 6–12 mm. lt. Petala calyce sesquilongiora.

β. ensifolia, *Williams.*

SYN. *A. lanuginosa*, var. γ. *ensifolia*, Rohrb. l. c.

Caules laxi pilis paucis adspersi. Folia anguste linearia et subulata, nervo centrali subtus valde prominente, 20 mm. lg., approxim. ½–1 mm. lt. Petala e calyce exserta.

Lusus 1:—Folia subtus pilis paucis adspersa, ceterùm glabrescentia.

Lusus 2:—Folia utrinque dense hirsuta.

γ. tucumanensis, *Williams.*

SYN. *A. diffusa*, var. *tucumanensis*, Griseb. in Götting. Abhandl. xxiv. p. 27 (1879).

Folia elliptica vel elliptico-oblonga, mucronulata.

I think that varr. γ and δ of *A. lanuginosa*, Rohrb., should form a distinct species. The petals are exserted from the calyx as is the case in var. *tucumanensis* (of which there are specimens in Herb. Kew.) and there are other distinctive characters. The species is limited to S. Mexico and N. Argentina. Like *A. nepalensis* it is found clambering 9–15 decim. among bushes and shrubs (vide *Pringle*, Pl. Mexican. 1894, no. 4641).

Geogr. limits.—*N.* Mexico: Mt. Orizaba in prov. of Vera Cruz (var. β).

S. & E. Argentina: prov. of Tucuman (var. γ).

W. Mexico; Chinautla in prov. of Puebla (var. β).

70. A. SORATENSIS, *Rohrb. in Linnæa*, xxxvii. p. 266 (1871–72); *Jacks. Ind. Kew.* i. p. 181.

Radix repens. Caules multi adscendenti-erecti, simplices vel paullum breviter ramosi, pilis reversis brevibus, superne densius hirtello-pubescentes ad summum, 20 centim. Folia ovato-lanceolata vel anguste ovata, marginato-incrassata, axillis inferioribus fasciculiferis, acuminata, superne pilis brevissimis sparsis, ad marginem versus et subtus nervo mediano paullum prominente densioribus, reversis scabrida, binorum oppositorum altero ad caulis ramorumque basin sterili, ad apicem florifero, altero rarum fere semper abbreviatum contractum ferente. Flores longe pedicellati, pedicellis patentibus nisi apice arcuato-erectis, pilis reversis densis griseo-scabridis. Calyx ovoideo-campanulatus, basi rotundatus; sepala ovato-lanceolata acuminata, apice nigricante recurvo, margine scarioso ciliato, nervo mediano prominente scabrido. Petala alba ovato-oblonga obtusa, calyce paullum longiora. Semina fusco-atra, lenticularia.

Differt hæc, quæ *A. lanuginosæ* affinis est, ab illa habitu, floribus multo majoribus calycisque structura diversissima.

Description verified from unnamed specimens in Herb. Kew. labelled "Mandon, no. 959," collected in 1858. In a medium-size capsule there were 22 seeds.

Hab. Bolivia: near Sorata in prov. of Larecaja (*Mandon*, no. 959).

71. A. PLEURANTHA, *Phil. in Anal. Univ. Santiago*, 1893, p. 763; *Reiche & Johow, Fl. de Chile*, p. 191 (1896).

Glabra, perramosa, 12 centim. Radix gracilis. Caules ramosi, adscendenti-erecti, ramis teneris. Folia oblonga obtusa, basi in petiolum brevem attenuata, obsolete nervata, margine lævia vix incrassata. Sepala 4 mm. longa, ovato-lanceolata, apice acuta recta. Petala 6 mm. longa, calycem superantia, alba, obtusa. Semina rufo-atra, globoso-reniformia.

The original description of this plant by Philippi is very brief and scarcely diagnostic. As far as it reads it might apply almost equally well to *A. parvifolia*; and from the description alone as applying to Hartweg's specimens from the Andes of Ecuador, I was disposed to sink it in this species. There are, however, authentic specimens from Philippi in Herb. Kew., and from these is drawn up a fresh description, in which satisfactory points of difference between the two plants are recognizable.

It is from an examination of these specimens that its position in the genus is determined. In the 'Flora de Chile,' cited above, in course of publication by Messrs. Reiche and Johow, the short description is only a Spanish translation of Philippi's Latin diagnosis, without additional characters. In habit the plant rather resembles *A. palustris*.

Hab. Chile: found by F. Delfin on the banks of the river Palena in 1887.

The name of the species is probably derived from the axillary flowers.

72. A. PARVIFOLIA, *Benth. Plant. Hartweg.* p. 163 (1839–48); *Rohrb. in Linnæa*, xxxvii. p. 272 (1871–72).

α. spathulæfolia, *Rohrb. in Linnæa*, xxxvii. p. 272 (1871–72).

Caules et folia indumento vario. Folia ovato- vel lanceolato-spathulata in petiolum brevem ciliatum attenuata, mox acuta mox obtusa. Petala nunc nulla, nunc parva vel evanescentia.

Lusus 1:—Caules glaberrimi vel unifariam puberuli. Folia glabra, petiolo ac nervo mediano ciliatis exceptis, acuminata. Flores breviter pedicellati, apetali.

SYN. *A. parvifolia*, Benth. (sensu limitato).

Hab. In the Andes of Ecuador; Hacienda de Antisana: in the Andes of Colombia (*Purdie*).

Lusus 2:—Caules glabri vel leviter puberuli. Folia nunc glabrescentia punctulataque nunc sparse pilosa, acuta vel obtusiuscula. Flores in eodem specimine mox longe mox breviter pedicellati, pedicellis glabris vel puberulis; petala in floribus his adsunt, in illis deficiunt.

Hab. In the Andes of the republic of Ecuador: near the snow-line of Mt. Pichincha, on the line of the Equator. Mountains of Mexico: Mt. Orizaba; and Chinautla, in the prov. of Puebla.

Lusus 3:—Caules et folia latere superiore pilis densis rigidis griseo-hirsuta. Flores breviter pedicellati. Calyx omnino dense pubescens. Petala semper adsunt.

Hab. Mexico: Mt. Orizaba.

β. Schiedeana, *Rohrb. in Linnæa*, xxxvii. p. 273 (1871–72).

Caules humifusi, nunc glabri nunc puberuli. Folia anguste lanceolata ad basin versus ciliatam vix angustata, acuta vel obtusiuscula, glabra vel pubescentia. Flores apetali, nunc longe nunc breviter pedicellati.

Lusus 1:—Caules et folia minima, 2–3 mm. lg., dense puberula. Flores paullum minores, calyce pubescente.

Hab. In the Andes of the republic of Ecuador: Hacienda de Antisana.

Lusus 2:—Caules et folia glabrescentia. Sepala glabra, carinâ exceptâ.

SYN. *A. scopulorum*, Schlecht. in Linnæa v., et xii., *non* H. B. et K. *A. Schiedeana*, Fenzl ms.

Hab. Mexico: just below the snow-region of Mt. Orizaba, 3150–4420 metres; also at Sempaaltepec.

Geogr. area. Mexico, Colombia, and Ecuador.

73. A. REPTANS, *Hemsl. Diagn. Pl. Nov. Mexic.* p. 22 (1879); *Biol. Centr.-Amer., Bot.* i. p. 70.

Radix gracilis, e collo ramosa, ramis tenuibus debilibus reptantibus ad nodos radicantibus angulatis hispidulo-pilosis. Folia obtusa vel apiculata, sparsim punctata, obovato-lanceolata, axillis plerumque fasciculiferis. Sepala ovato-oblonga vel lanceolata, obtusa late membranaceo-marginata. Petala nulla. Semina lenticularia, rufo-atra, longe funiculata.

Hab. Valley of Mexico (type-specimens); and prov. of Michoacan (*Pringle*).

β. Pringlei, *var. nova.*

Nana, cæspitosissima (*Pringle*, Pl. Mexicanæ, 1894, no. 4724).

Hab. Sierra de San Felipe, prov. of Oaxaca, at 3000 metres.

Geogr. area. Mexico.

b. Sepala enervia puberula. (Petala nulla.)

74. A. JAMESONIANA, *Rohrb. in Linnæa,* xxxvii. p. 267 (1871–72); *Jacks. Ind. Kew.* i. p. 179.

Radix sublignosa, gracilis. Caules permulti laxe adscendenti-erecti graciles albidi glabrescentes, 5–8 centim. Folia parva, anguste lineari-lanceolata acuta, nervo mediano subtus valde prominente, margine præsertim ad basin membranaceam versus ciliata. Pedicelli glabrescentes, haud rarò folium superantes. Sepala anguste ovato-lanceolata, anguste membranaceo-marginata, breviter puberula, acuminata. Ovarium globosum. Capsula ovata. Semina lenticularia.

Hab. Republic of Ecuador: summit of Mt. Pichincha in the Andes, 4700 metres.

c. Sepala concava uninervia vel obsolete 3-nervia, glaberrima.

75. A. LYCOPODIOIDES, *Willd. Herb.* no. 8793, ex *Schlecht. in Gesellsch. naturf. Fr. Berl. Mag.* vii. p. 212 (1813); *H. B. & K. Nov. Gen. et Spec.* vi. p. 27.

The specimens on the next sheet of Willdenow's herbarium named *A. decussata,* Willd. herb. no. 8794, are more compact in habit, but are not otherwise sufficiently different to justify their separation as a distinct species.

Hab. Mexico.

SYN. *A. decussata,* Willd. Herb. *ap.* Schlecht. in Gesellsch. naturf. Fr. Berl. Mag. vii. p. 212 (1813).

76. A. ROHRBACHIANA, *Garcke, in Linnæa,* xxxvii. p. 311 (1871–72).

Omnino glabra. Caules adscendenti-erecti crassi 4-angulares neque vero sulcati, ramosi, ramis erectis. Folia anguste linearia, erecta vel patentia, demùm sæpe reflexa, plana, interdum basin versus ciliolata, acuminata neque raró mucronulata. Pedicelli longi, basi subcrassiores, primùm erecti, demùm patentes vel reflexi. Sepala ovato-oblonga late membranaceo-marginata, obsolete trinervia. Petala alba elongato-oblonga obtusa, calyce sesquilongiora. Semina oblongo-lenticularia.

Resembles a small-leaved form of *Stellaria glauca,* but petals not bifid.

Hab. Mexico.

Subsectio 3.—Flores solitarii, terminales.

77. A. ORBIGNYANA, *Wedd. in Ann. Sci. Nat.* Sér. V. i. 1864, p. 293; *Rohrb. in Linnæa,* xxxvii. p. 254.

Pumila, glabra. Caules cæspitem parvum formantes, 3–5 centim., breviter ramosi. Folia subimbricata lineari- vel subspathulato-lanceolata acuta, margine præsertim basin versus serrulato-ciliata. Pedicelli apicem versus puberuli. Sepala ovato-lanceolata vix obtusa. Petala alba obovato-lanceolata obtusa, calycem vix æquantia. Stamina 5, calyce breviora.

Hab. Republic of Bolivia: in the Andes, near Potosi.

78. A. CATAMARCENSIS, *Pax, in Engl. Bot. Jahrb.* xviii. 1893, p. 29.

Humilis, pilis brevibus recurvis scabra, glaucescens. Caulis ramosus. Folia linearia vel anguste lanceolata acuminata

crassiuscula, margine fere cartilagineo dense ciliata, nervo mediano subtus prominente. Pedicelli scabri. Sepala lanceolata acuminata, præsertim interiora late hyalino-marginata, omnia secus nervum medium scabrida, ceterùm vix glabrescentia, post anthesin paullo accrescentia. Petala calycem æquantia vel superantia, obovata obtusa, breviter unguiculata. Stamina 10, petalis breviora. Ovarium subglobosum.

Hab. Argentina.

79. A. ACHALENSIS, *Griseb. in Gött. Abhandl.* xxiv. p. 26 (1879); *Jacks. Ind. Kew.* i. p. 178.

Serpens, perramosa, glabra, dense cæspitosa. Rami debiles, $2\frac{1}{2}$–7 centim. Folia elliptica vel lanceolato-elliptica acuta, basi angustata, margine inferne ciliolata. Sepala ovato-oblonga subacuta. Petala nulla. Semina lenticulari-subrotunda rubicunda. Ovarium globosum.

Habitus *A. serpentis*, sed folia fere *A. serpyllifoliæ* et corollâ deficiente accedit ad *A. confertam* ubi folia "imbricata" (ex descriptione).

Hab. S. Achala in Argentina.

Both this species and the preceding might by some botanists be considered as varieties of *A. serpens*: all three are found in Argentina.

80. A. SERPENS, *H. B. & K. Nov. Gen. et Spec.* vi. p. 32 (1823); *Rohrb. in Linnæa,* xxxvii. p. 268 (1871–72).

Stirps valde variabilis, præsertim foliorum forma, quæ etiam in eodem specimine nunc obtusa sunt nunc acuta, eorumque indumento. Varietates certis limitibus vix distingui possunt.

α. genuina, *Rohrb. in Linnæa,* xxxvii. p. 269 (1871–72).

Caules procumbentes ac serpentes raro diffusi et adscendenti-erecti, haud dense cæspitosi, fuscescentes, glaberrimi vel hirtelli. Folia mox obtusa mox acuta. Flores fere semper breviter pedicellati, pauci.

Lusus 1:—Caules procumbentes ac serpentes glaberrimi. Flores breviter pedicellati. Petala calycem paullum superantia.

SYN. *A. serpens,* H. B. & K. l. c.
A. pauciflora, Willd. herb. no. 8788.

Lusus 2:—Caules procumbentes ac serpentes, ramulis hirtellis. Flores breviter pedicellati. Petala calyce sesquilongiora.

SYN. *A. digyna*, Willd. herb. no. 8738; Schlecht. in Gesellsch. naturf. Fr. Berl. Mag. vii. p. 201 (1813).
A. scopulorum, H. B. & K. Nov. Gen. et Spec. vi. p 31.

Lusus 3:—Caules diffusi adscendenti-erecti glaberrimi. Flores nunc breviter nunc longe pedicellati. Petala calyce ferè duplo longiora.

β. andicola, *Gill.* (sp.) *in Hook. Bot. Miscell.* iii. p. 148 (1833); *Rohrb. in Linnæa*, xxxvii. p. 270 (1871–72).

Lusus 1:—Caules laxi glaberrimi.

SYN. *A. serpylloides*, Naud. in C. Gay, Fl. Chilena, i. p. 271.
A. cæspitosa, Phil. in Linnæa, xxviii. 1856, p. 675.

Lusus 2:—Caules laxi, sub nodis pilis brevissimis farinosi.

SYN. *A. multicaulis*, Phil. in Linnæa, xxviii. 1856, p. 673.

Lusus 3:—Caules pusilli glaberrimi densi, vix 2–3 centim. alti; flores 2 mm. longi, sepalis carnosis.

SYN. *A. rivularis*, Phil. Florula Atacam. p. 10 (in descriptione calycis sepala false acuta [aucta?] dicuntur).
A. brachyphylla, Phil. Pl. Nuev. Chilens., in Anal. Univ. Chile, 1893, p. 762.

Re hujus speciei polymorphæ et variabilis Peyritsch in *Linnæa*, xxx. p. 58 recte *Arenariam serpentem* ac *A. scopulorum* conjungendas esse animadvertit. Illius folia sunt obtusa ac nisi ad basin versus ciliatam glabra, hujus acuta totoque margine ciliata. Occurrunt autem specimina perplurima, quæ nunc foliis gaudent acutis nunc obtusis atque plus minus ciliatis. Idem valet de caulis ac pedicellorum indumento horumque cum calyce proportione. Ceterùm *A. serpens* valde affinis est *Arenariæ parvifoliæ*, imprimis ejus var. *Schiedeana*; sed ceteris omnibus notis neglectis, jam primo aspectu illa sepalis acutis differt.

As with *A. lanuginosa*, Rohrbach devoted a considerable amount of attention to the material accumulated for the elucidation of this species; and after examination of the specimens again I am inclined to coincide almost exactly with his views as to the circumscription and limitation of these two species. Under various forms they have a wide and extensive range in Central and South America, and it is scarcely possible to recognize so many distinct species as have been described by Prof. Philippi within the limits of Chile. Specimens of the same plant, described in somewhat different words, have been ranked as new species, from the neighbouring republics of Bolivia, Brazil, and Ecuador.

A. serpens, var. *Orizabæ*, Rohrb. = *A. bryoides*.

Geogr. limits.—*N. & W.* Mexico: Cerro Leon in prov. of Guanajuato. *E.* Brazil.

S. S. Chile: in the Andes of the district of Chillan (*A. multicaulis*, Phil.).

Subsectio 4.—Flores axillares solitarii, et terminales subconferti.

81. A. MICROPHYLLA, *Phil. in Linnæa*, xxviii. p. 673 (1856); *Rohrb. in Linnæa*, xxxvii. (1871–72) p. 270 (*syn.* A. serpens, *var.* andicola).

Glabra. Caules breves ascendenti-erecti, non dense cæspitosi. Folia minima oblonga obtusa parùm remota. Sepala ovata obtusa. Petala alba, calycem superantia. Semina lenticulari-reniformia.

Reduced by Rohrbach to *A. serpens* var. *andicola*,—"forma foliis minutis, floribus confertis." Allied rather to the next species, from which it is at once distinguished by the obtuse and more distant pairs of leaves. Philippi's brief description scarcely serves to distinguish the plant.

Hab. Chile: in the Andes of prov. of Coquimbo.

82. A. PALUSTRIS, *Naud. in C. Gay, Fl. Chilena*, i. p. 271 (1845); *Rohrb. in Linnæa*, xxxvii. p. 257 (1871–72).

β. patagonica, *Phil.* (sp.) *in Linnæa*, xxviii. p. 671 (1856); *Reiche & Johow, Fl. de Chile*, p. 192 (1896).

SYN. *A. fastigiata*, Phil. in Linnæa, xxviii. p. 673 (1856).

Though included in the flora of Chile mentioned above, this variety is found at the lake of Nahuelhuapi in the Argentine Republic, on the other side of the Andes. The specific type in Chile always occurs on the borders of lakes. Var. β seems to be more widely distributed than the type; and the limits given below all refer to localities in which var. β occurs. In Chile this variety has been recorded under the name of *A. fastigiata*, Phil.

Geogr. limits.—*N.* Chile: district of Linares.

S. & E. Argentina: Lake Nahuelhuapi.

W. Chile: lake of Llanquihué in prov. of Valdivia.

Subsectio 5.—Flores longe pedicellati, in cymas paucifloras dispositi.

83. A. Stuebelii, *Hieron. Pl. Stuebel.*, in *Engl. Bot. Jahrb.* xxi. 1895, p. 307.

Glauca. Caules permulti adscendenti-erecti subsimplices vel basi ramosi, pilis reversis brevibus minutis superne densius subhirtello-puberuli, 10 centim. Folia lineari-lanceolata, acuta vel subacuminata, utrinque puberula (pilis brevissimis sparsis), ad marginem versus et subtus nervo mediano prominente scabrida (pilis reversis). Pedicelli longi erecti scabrido-puberuli. Sepala ovata; exteriora acuminata anguste membranaceo-marginata scabrida basi ciliata dorso carinata, interiora obtusa breviter mucronata late membranaceo-marginata. Petala alba ovato-oblonga leviter emarginata. Ovarium ovatum.

Hab. Bolivia.

84. A. saxosa, *A. Gray, Pl. Wright.* ii. p. 18 (1853), ex *Smiths. Contrib.* v.; *Robinson, in Proc. Amer. Acad.* xxix. p. 293 (1894).

Viridis, leviter puberula. Caules 5–50 centim., simplices vel utplurimum a basi ramosi permulti decumbentes dein erecti. Folia oblongo-lanceolata uninervia subglabra, obtusa vel apiculata, subsessilia vel in petiolum brevem contracta. Sepala ovato-oblonga acuta glabra membranaceo-marginata, nervo valido. Petala calycem æquantia. Semina lenticularia.

β. cinerascens, *Robinson, in Proc. Amer. Acad.* xxix. p. 293. Rigidior cinerascens. Folia pungentia. (*Herb. Columbia Coll.*)

Hab. Huachuca Mtns., in Arizona (*J. G. Lemmon*).

This is a species of wide range, occurring alike in rocky subalpine regions and much lower upon sandy banks, accordingly varying much in height and diffuseness of branching. The character of the seeds is not given in the original description, but in the specimens in Herb. Kew. they are lenticular, smooth and shining: I have no hesitation therefore in placing the plant in this subgenus. Mr. B. L. Robinson says that it shows transition to typical forms of *A. lanuginosa*; but its diagnostic characters do not warrant its reduction to that polymorphous species.

Geogr. limits.—*N.* United States: Colorado.

S. & W. Mexico: Lower California.

E. United States: Guadeloupe Mtns. in Texas.

85. A. SPATHULATA, *Desf. Fl. Atlantica*, i. p. 158 (1798); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 619.

De Candolle says that in the authentic specimens he examined (Prodr. i. p. 413) the capsule had only five valves after dehiscence; but J. Gay, who examined similar authentic specimens, traverses this statement. What is certain is that in Schimper's authentic specimens from the *loçus classicus*, the capsule is deeply 6-valved, and there are remains of three styles distinct at the base. Boissier's Spanish specimens are those which seem to most nearly agree with the type-specimens, labelled *Stellaria Arenaria*, in Linnæus's own herbarium.

Geogr. limits.—*N.* Andalusia: environs of Seville.
S. Mekinez, in Marocco. *E.* Constantine, in Algeria.
W. Puerto de Sta. Maria, on the bay of Cadiz.

SYN. *A. cerastioides*, Poir. Voy. Barb. ii. p. 166 (1789)?
A. hispanica, Spreng. Syst. Veg. ii. p. 396.
Cerastium arenarioides, Crantz, Instit. ii. p. 402 (1766).

Subsectio 6.—Flores ad ramorum apicem conglomerati sessiles, vel dichasium valde compositum formantes.

a. Folia ovata obtusa. Sepala obtusa.

86. A. MANDONIANA, *Wedd. in Ann. Sci. Nat.* Sér. V. i. 1864, p. 294; *Jacks. Ind. Kew.* i. p. 180.

Dense pulvinato-cæspitosa. Caudicis rami lignosi plus minus abbreviati. Folia fere navicularia, supra glabra, subtus villosa, margine ciliata. Flores 3–5-conglomerati, foliis supremis involucrati. Sepala ovata, margine villosa. Petala nulla.

I know of no other reference to this plant than that given above. The short description is scarcely more than sufficient to determine its position in the genus, and the damaged specimens are too fragmentary to add much more.

Hab. Bolivia (*Mandon*, no. 961).

b. Folia angusta acuminata. Sepala acuta.

87. A. PEYRITSCHII, *Rohrb. in Linnæa*, xxxvii. p. 264 (1871–72); *Jacks. Ind. Kew.* i. p. 180.

Caules laxi erecti quadrangulares, paullum breviter ramosi, pilis crispulis reversis, præsertim ad binos angulos, scabridi. Folia lineari-lanceolata, margine dorsoque ciliata. Flores ad caulis apicem dichasium valde compositum formantes, bifurca-

tionum ramis diffusis, alternis fere semper abbreviatis, longe pedicellati, pedicellis capillaribus dense pubescentibus: bracteæ parvæ folia æquantes. Sepala ovato-lanceolata, dorso carinata, carina viridi dense pilosa, ceterum membranacea ac glabrescentia. Petala alba oblonga acuta, calyce triente breviora.

SYN. *A. diffusæ*, Elliott, affinis, fortassis species nova, *ap.* Peyritsch, in Linnæa, xxx. p. 58.

Species *A. megalanthæ* atque *A. pleuranthæ* valde affinis, tamen inflorescentia distinctissima primo aspectu diversa est. Etiam ad speciem sequentem accedit, quæ habitu, calycis structurâ, petalis obtusis et caulis pubescentiâ distingui potest.

The species is found in marshy localities, under similar circumstances as *A. palustris*.

Hab. Mexico: Real del Monte and Cerro Ventoso, also at San Miguel near Toluca at 2770 metres.

88. A. POEPPIGIANA, *Rohrb. in Linnæa*, xxxvii. p. 265 (1871-72); *Jacks. Ind. Kew.* i. p. 180.

Caules humifusi longe repentes quadrangulares, ramos plurimos breves dense foliosos steriles, paucos elongatos minusque dense foliatos, apice floriferos, laxeque adscendenti-erectos, 5-20 centim., edentes, æque ac ramuli pilis brevibus simplicibus stellatisque intermixtis hirtulo-pubescentes. Folia linearia vel anguste lineari-lanceolata, basin versus subattenuata, plus minus dense, præsertim ad marginem nervumque medianum, puberula, in ramulis sterilibus subimbricata. Flores ad ramulorum apicem dichasium plus minus compositum laxum formantes, longe pedicellati, pedicellis puberulis: bracteæ parvæ lineari-setaceæ mucronulatæ. Sepala oblonga anguste membranaceo-marginata, exteriora omnino puberula, interiora nervo mediano leviter hirsuto excepto glabrescentia. Petala alba oblonga obtusa, calyce sublongiora.

Species non minus quam prior *A. megalanthæ* affinis est; differt autem habitu, præsertim ramis illis dense foliatis sterilibus ac florum dispositione, caulis pubescentiâ, demùm calycis structurâ.

Hab. Cassapi, in the Peruvian Andes.

Sectio iv. PORPHYRANTHEÆ.

89. A. PURPURASCENS, *Ram.* ap. *DC. Fl. Franç.* iv. p. 785 (1805); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 628.

De Candolle's figure is sometimes cited as the earliest publi-

cation of this species; but as Alphonse de Candolle points out, vol. iv. of the 'Fl. Française' was published in 1805, *not* in 1815 as printed in many copies. P. B. Webb (Iter. Hispan. p. 62) claims to have found this species on Sierra Nevada in Andalusia, —"in stagnis elatis prope verticem." But, as Prof. Willkomm asserts, since neither Boissier nor any other botanist who has explored and examined the vegetation of this mountain chain has ever found there this Pyrenean plant, it is extremely probable that P. B. Webb incorrectly identified his specimens. But for the smooth seeds, it could be referred to *Cerastium*.

Hab. The Pyrenees (French and Spanish sides) and in the Cantabrian Mountains.

Iconogr.—*DC. Ic. Plant. rar. Gall.* 45 (1808); *Bot. Mag.* t. 5836.

SYN. *A. cerastioides,* Pers. Syn. Plant. i. p. 502.
Cerastium purpurascens (*non* Adams), Fenzl, Verbreit. Alsin. t. ad p. 56.
C. Ramondi, Fenzl, *ex* Benth. & Hook. f. Gen. Plant. i. p. 149.
Dufourea purpurascens, Gren. in Act. Soc. Linn. Bord. 1837, p. 25.

Sectio v. EREMOGONEÆ.

Subsectio 1.—Axillæ foliorum non fasciculiferæ.

A. Flores subsessiles, in cymis capitato-aggregatis vel glomerato-fasciculatis.

90. A. CEPHALOTES, *Bieb. Fl. Taur. Cauc.* i. p. 346 (1808), et iii. p. 309; *Ledeb. Fl. Rossica,* i. p. 361.

Caudex polycephalus crassus, caules erectos edens. Folia turionum prælonga curvata, margine ciliis asperis scaberrima; folia caulium duplo latiora breviora, superiora rigida adpressa. Ochrea brevis. Flores in thyrsum compactum turbinatum vel hemisphæricum conferti; bracteæ latæ subulatæ rigidæ elongatæ. Sepala ovata acuminata obtusa carinata. Petala e basi sublatiore rotundatâ oblonga obtusa, calycem subsuperantia vel eum æquantia.

Described from Rehmann's specimens in Herb. Kew.

Geogr. area.—S. Russia.

N. South part of the prov. of Podolia.
S. Prov. of Kherson, near Odessa.
W. Prov. of Bessarabia.

E. Prov. of Kherson (*Rehmann*, Exsicc. It. Cherson, no. 27).

SYN. *Eremogone cephalotes*, Fenzl, Verbreit. Alsin. t. ad p. 46.

91. A. CONGESTA, *Nutt.* ex *Torr. & Gray, Fl. N. Amer.* i. p. 178 (1838); *Robinson, in Proc. Amer. Acad.* xxix. p. 295 (1894).

Nuttall in his MS. description says, "a remarkable species, resembling in habit *Dianthus prolifer.*"

β. suffrutescens, *Robinson in Proc. Amer. Acad.* xxix. p. 295.

Caudex sæpius lignosus crassus. Capitula umbellatim sphærica; floribus paullum minoribus.

SYN. *Brewerina suffrutescens*, A. Gray, in Proc. Amer. Acad. viii. p. 620 (1872).

A form too well marked in its foliage, ligneous caudex, and allium-like inflorescence to be united with the typical *A. congesta.* The capitellate stigmata are not of generic importance.

γ. subcongesta, *S. Wats. Bot. Calif.* i. p. 69; *Robinson, in Proc. Amer. Acad.* xxix. p. 295.

Caudex plus minus lignosus. Caules glabri vel pulverulento-pubescentes, sæpius geniculati nodis valde tumescentibus. Flores minus congesti, in cymas dichotomas conferti. Sepala ovata acuminata.

SYN. *A. Fendleri* var. *subcongesta*, S. Wats. Bot. King Exped. p. 40.
A. Fendleri var. *glabrescens*, S. Wats. l. c. p. 40.

δ. Kingii, *Jones* (sp.) *in Proc. Calif. Acad. Sci.* ser. 2, v. p. 627; *Gray & Robinson, Syn. Fl. N. Amer.* i. p. 241 (1897).

Flores in cymas dichotomas conferti, petalis emarginatis. Planta superne glanduloso-pubescens.

Hab. Humboldt Mtns. in N. Nevada, and S. Utah.

Geogr. area.—W. Canada and W. United States.

N. Canada: Cypress Hills in prov. of Assiniboia.
S. Arizona. *W.* Colorada.
E. Rocky Mountains of California.

Iconogr.—*S. Wats. Bot. King Exped.* p. 39, t. 6. figs. 1–3 (*Stellaria Kingii*).

92. A. FRANKLINII, *Dougl.* ex *Hook. Fl. Bor.-Amer.* i. p. 101, t. 35 (1833); *Robinson, in Proc. Amer. Acad.* xxix. p. 297 (1894).

Specimens collected by Douglas at source of the Missouri may well have been the next species.

Hab. N.W. United States: Oregon and Washington.

93. A. Hookeri, *Nutt. in Torr. & Gray, Fl. N. Amer.* i. p. 178 (1838); *Robinson in Proc. Amer. Acad.* xxix. p. 297 (1894).

This species, with much the habit of the preceding, differs in its much denser caudex and constantly pubescent stem. The stem is terete even in a dried state, while the stems of *A. Franklinii* in drying become furrowed and angulate, as though slightly fleshy. The slightly exserted petals are also characteristic. It can scarcely be considered a variety of the preceding.

Hab. United States: Colorado, Wyoming, Nebraska, and Montana.

94. A. polycnemifolia, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 48 (1842); *Fl. Orient.* i. p. 692.

Glauca. Folia turionum brevia stricta setacea mucronata. Capitulum pauciflorum (floribus 3–6), bracteis involucratum; bracteæ lineari-lanceolatæ acuminatæ viridi-carinatæ. Sepala oblongo-lanceolata acuta late membranaceo-marginata carinata, nervo ad apicem usque producto. Petala alba oblongo-linearia, basi vix attenuata, calyce sublongiora.

The bracts do not seem to be "abbreviatæ," as in Boissier's description. But the description may be based on Aucher-Eloy's specimens numbered 4255, in which the heads of flowers are very much crushed and mutilated, and in which it is not possible to ascertain the length of the bracts. Sintenis's specimens, determined by Prof. C. Haussknecht, show the structure of the fascicles of flowers very clearly, and from these specimens the description has been revised.

Geogr. limits.—N. & W. Turkish Armenia: Ketsetvikale, near Gumuchkhane, in prov. of Trebizond (*Sintenis*, It. Orientale, 1894, no 6111).

S. & E. N. Persia: Mt. Demawend, in the Elburz Mountains.

B. Flores pedicellati, in cymas simplices aut compositas interdum depauperatas vel per thyrsum brachiatum paniculæ- vel corymbiformem dispositi, pedicellis calyci æquilongis vel longioribus suffulti.

a. Petala sepalis breviora.

95. A. pungens, *Clem. in Lag. Gen. et Spec. Nov.* p. 15, no. 199 (1816); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 625.

This very distinct and remarkable species is limited in Europe to the range of the Sierra Nevada, and forms broad hemispherical bristly tufts from 50 to 20 centim. high, growing on the alpine slopes and also above the snow-line at 1750 to 2700 metres. As J. Gay points out, in plants raised from seed in the Paris Botanic Garden, the whole plant is glaucous, and not as one sees it in Boissier's otherwise well-coloured plate. It was only a considerable time afterwards that glabrous specimens referable to this species were found in S. Marocco, by Mr. E. Cosson and Mr. John Ball. In all the specimens I examined the seeds appeared to be quite smooth, and free from elevated tubercles, neither had they the rough surface mentioned in Willkomm's description. This was also certainly the case in the Marocco specimens.

β. glabrescens, *Ball, in Journ. Bot.* 1873, p. 301.

Differt a typo Hispanico, sepalis glabris, nervo mediano basin versus ciliato, caulibus glabris, foliis ad basin membranaceam connatis ciliatis, antheris fusco-griseis nec rubentibus.

Geogr. limits.—N. & E. Andalusia: southern slopes of Sierra Nevada.

W. Mt. Ouensa, to the south of the city of Marocco, a spur of the Great Atlas, var. β (*Cosson*, 1873).

S. Tâcherat, on the Anti-Atlas, still further south, var. β (*Ball*).

Syn. *Eremogone pungens*, Fenzl, Verbreit. Alsin. t. ad pp. 57 et 59.

b. Petala calycem æquantia, vel sæpius eo longiora.

96. A. Holostea, *Bieb. Fl. Taur. Cauc.* i. p. 345 (1808); *Ledeb. Fl. Rossica*, i. p. 364.

Lusus 1:—cyma puberula (forma normalis).

Lusus 2:—cyma glaberrima (spec. in *Willd.* herb. no. 8751).

Geogr. limits.—N. Cis-Caucasia; prov. of Terek, along the river Terek between Balta and Larsk.

S. Turkish Armenia: Bayazid.

W. Cis-Caucasia: prov. of Terek, Mt. Kazbek in the Central Caucasus, 14 miles from the northern limit, at 2750 metres (*C. A. Meyer*).

E. Cis-Caucasia: prov. of Daghestan.

Syn. *Eremogone Holostea*, Rupr. Fl. Caucasi, p. 217.

97. A. LYCHNIDEA, *Bieb. Fl. Taur. Cauc.* i. p. 347 (1808), et iii. p. 309; *Ledeb. Fl. Rossica,* i. p. 366.

Admissa a Ledebour species subdubia et probabiliter varietas stenopetala *A. formosæ*, Fisch., postea conjuncta est a b. E. Regel cum *A. capillari*, Poir.; sed hæc planta in cymæ plurifloræ pedicellis elongatis, petalis ellipticis basi vix attenuatis, et imprimis glandulis 5 brevibus truncatis staminiferis est certe distincta.

The specimens in Herb. Kew. are from the source of the R. Argun (1881).

Geogr. range.—*N.* Trans-Caucasia: prov. of Tiflis, at the source of the R. Argun.

E. Trans-Caucasia: prov. of Tiflis, Azunta in the Caucasus, at 3350 metres (*Ruprecht*, Fl. Caucasi, p. 219).

S. & W. Turkish Armenia: Mt. Ararat.

SYN. *A. setacea* (non Thuill.), Fisch. *ex* Ser. in DC. Prodr. i. p. 402.
Eremogone lychnidea, Rupr. Fl. Caucasi, p. 219.

98. A. ACUTISEPALA, *Haussk. ined. in exs., Sintenis, It. Orientale,* 1890, no. 2764.

22 centim. Omnino glabra, glaucescens. Folia turionum lineari-setacea cuspidato-acuminata incrassato-marginata, caulina magis pungentia. Flores in cymas compositas multifloras dispositi. Sepala late membranaceo-marginata, 2 interiora ovata acuminata, 2 exteriora lanceolata longe attenuato-acuminata, intermedium lanceolato-ovatum longe attenuato-acuminatum. Petala elliptico-oblonga, apice subcucullata, calycem duplo superantia.

Hab. Turkish Armenia: on bare hills near Salachlu in the district of Egin, prov. of Diarbekir.

99. A. SZOWITZII, *Boiss. Fl. Orient.* i. p. 695 (1867); *Jacks. Ind. Kew.* i. p. 181.

23 centim. Glabra. Caudiculi prostrati. Caules debiles, basi foliorum denudati. Folia stricta setacea scabrida. Cyma 1–4-flora; flores alares supra medium pedicellis braceati, bracteis scariosis incurvis linearibus acuminatis. Sepala pallida oblongo-lanceolata acuminata anguste scariosa. Petala oblonga, calyce sublongiora.

Ab *A. Holostea* differt, caudiculis prostratis, caulibus adscendentibus basi denudatis, sepalis 6 mm. longis anguste scariosis.

Boissier's description is very short. The above has been drawn up from authentic specimens ex Herb. Hort. Petropolit., labelled "Armenia," but without precise locality.

Hab. Persian Armenia: Dilman, near Lake Urumiah.

100. A. COMPACTA, *Coville, in Proc. Biol. Soc. Wash.* vii. p. 67; *Robinson, in Proc. Amer. Acad.* xxix. p. 295 (1894).

Glauca. Caules graciles circiter 3 centim., fere foliorum denudati. Folia turionum glandulosa ciliata. Sepala ovato-lanceolata acuminata. Petala calycem excedentia.

Hab. California: mountains of Tulare Co. (1891).

Iconogr.—*Coville in Contrib. U. S. Herb.* iv. p. 70, t. 5.

101. A. ISAURICA, *Boiss. Fl. Orient.* i. p. 695 (1867); *Jacks. Ind. Kew.* i. p. 179.

Basi suffrutescens. Caules basi foliorum denudati. Folia turionum stricta lineari-filiformia margine scabrida, caulina multum longiora. Flores in thyrsum brevem pauciflorum subcorymbosum dispositi. Sepala carinata oblonga obtusa late viridia, anguste hyalino-marginata, apice nigricantia. Petala obovato-oblonga inferne attenuata, calyce duplo longiora.

Primùm Boissier eam habuit pro formâ *A. graminifoliæ*, a quâ longe differt caulibus basi nudis, sepalorum et petalorum formâ, et insigniter glandulis nullis.

Hab. Cilicia: alpine pastures of Mt. Ghei-dagh, in the Taurus range.

102. A. CUCUBALOIDES, *Smith, Plant. Ic. Ined.* i. p. 17, t. 17 (1789); *Boiss. Fl. Orient.* i. p. 695.

α. glabra, *Ledeb. Fl. Rossica*, i. p. 365 (*Willd.* herb. no. 8744).

Cyma et sepala glaberrima.

β. viscida, *Ledeb. Fl. Rossica*, i. p. 365.

Cyma et sepala viscido-puberula.

Geogr. limits.—*N.* Turkish Armenia: between Gumuchkhane and Baïburt, in prov. of Trebizond.

S. & W. Mt. Hassan-dagh, in prov. of Karamania (*Whittall*, exsicc. 1893, no. 153).

E. Russian Armenia, near Erivan.

Mr. Edward Whittall's specimens are interesting, as they considerably extend the range of the species.

Iconogr.—*Smith, l. c.*

SYN. *Eremogone cucubaloides*, Hohen. in Bull. Soc. Nat. Mosc. 1838, p. 401.
Arenaria gypsophiloides (non Linn.), Stev. *ex* Ledeb. Fl. Ross. i. p. 365.

103. A. JUNCEA, *Bieb. Fl. Taur. Cauc.* iii. p. 309 (1819); *Ledeb. Fl. Rossica*, i. p. 366.

α. typica, *Regel, Pl. Raddeanæ*, in *Bull. Soc. Nat. Mosc.* 1862, pt. 1, p. 364.

Cyma et sepala glanduloso-pubescentia.

β. glabra, *Regel, Pl. Raddeanæ, l. c.* p. 365.

Cyma et sepala glaberrinna.

Geogr. limits.—N. Along the R. Argun, near Nertschinsk, in the Siberian province of Trans-Baïkalia (*Turczaninow*, ex Ledeb. Fl. Rossica, i. p. 366).
E. Manchuria (*Maximowicz*, Pl. Mongol.).
W. Between the Yablonoi Mountains and Lake Baïkal (*Herb. Kew.* ex *Herb. hort. Petropolit.*).
S. China: Wei-chang near the source of the R. Ying-ho-Chuang-ho, in the prov. of Chihli (*Palibin*, in Act. Hort. Petropol. 1895, p. 111).

SYN. *A. dahurica*, Fisch. *ex* Cand. Prodr. i. p. 402.
Eremogone juncea, Fenzl, Verbreit. Alsin. p. 37.

104. A. SAXATILIS, *Linn. Sp. Plant.* p. 423 (1753), excl. omnia syn. [in ed. 2, septem]; *DC. Prodr.* i. p. 405.

Glabra. Caudices ramosi radicantes. Folia turionum lineari-setacea, recta vel heteromallo-curvata, margine scaberrima; caulina media filiformia; floralia lineari-subulata longe acuminata. Ochrea elongata sæpeque fissa. Cymæ ternæ breves, contractæ nec patulæ; floribus in thyrsum pauciflorum paniculæformem dispositis. Calyx ellipsoideus; sepala chartaceo-scariosa nitida, præter nervum dorsalem viridem, in mucronem herbaceum haud excurrentem flavescenti-albida, plana ecarinata late hyalino-marginata, apice rotundato-obtusa, omnia æqualia, ovalia vel sæpius late ovata. Petala alba obovata vel obovato-oblonga rotundata, calyce vix duplo longiora. Capsula oblongo-ovata.

As great confusion has unnecessarily arisen between specimens of this species and others referable to *A. longifolia* and *A. graminifolia*, the above is to a great extent transcribed from J. Gay's

MS. description of the Linnean specimen. Linnæus's brief description (Sp. Plant. ed. II.) is:—"Arenaria foliis subulatis, caulibus paniculatis, calycum foliolis ovatis obtusis"; which is not particularly characteristic. In 'Mantissa Plantarum' he cites as a synonym "Alsine arenaria: foliis subulatis, inferioribus longissimis," from *Gmelin*, *Fl. Sibir.* iv. p. 157, t. 63. f. 2; and this figure exactly represents the specimen in the Linnean herbarium. Fenzl then is wrong in separating the two plants, of which he refers one (the Linnean specimen) to *A. longifolia* ("fide speciminis cum Linneano comparati"), and refers the other (Gmelin's figure) to *A. graminifolia* (—Fenzl, in Ledeb. Fl. Rossica, i. pp. 362, 363). The two plants are identical, and, judging from the Linnean specimen, they could neither of them belong to *A. longifolia*, Bieb. In this specimen the sepals are quite plane and in no way carinate. In this respect, as in many other characters (few-flowered cymes, very obtuse sepals, oboval petals somewhat exceeding the calyx), it nearly agrees with *A. graminifolia*, though it cannot well be reduced to it. But it differs from the latter in its three contracted cymes with shortened pedicels, which gives it a different aspect, and also in its evidently smaller flowers. The arrangement and aspect of the flowers is almost exactly that of *Stellaria Holostea*. Linnæus gives as the geographical range, Germany, Switzerland, France, and Siberia. But though the last is correct, the distribution of true *A. saxatilis* in Europe includes Croatia, Transylvania, Roumania, and Central and Southern Russia; and in other countries the somewhat similar specimens should be referred to *A. graminifolia*.

As Gay himself suggests, the proper authority as well as type for this species is the actual specimen in the Linnean Herbarium. In the second edition of 'Sp. Plantarum' seven synonyms are given. In Gay's MSS. in the Kew Herbarium they are all referred to other species: taking them in the order in which they are given they may be disposed of as follows:—(1) *Alsine setacea*, Mert. et Koch; (2) *Alsine mucronata*, Linn.; (3) *Alsine verna*, Wahlenb., though Linnæus in 'Mant. Plant.' p. 72 transferred this synonym to *Arenaria verna*; (4) Vaillant's specimen is *Alsine setacea*, and Haller's specimen is *Alsine verna*; (5) *Alsine mucronata*; (6) *Alsine verna*; (7) possibly *Alsine tenuifolia*, Crantz, but uncertain.

Other synonyms usually referred to *A. graminifolia*, Schrad., should thus be referred to *A. saxatilis*:—*A. stenophylla*, Ledeb., Ind. hort. Dorpat, 1823, et Fl. Altaïca, ii. p. 165; *A. longifolia* (non Bieb.), DC. Prodr. i. p. 402 (the reverse is cited in 'Index Kewensis'); *A. procera*, Spreng. Hist. Rei Herb. ii. p. 268 (1808), et Hornem. Hort. Hafn. p. 424 (1813); *A. graminifolia*, var. α. *parviflora*, Ledeb. Fl. Rossica, i. p. 363; *A. otitoides*, Adams *ex* Cand. Prodr.; and finally *Eremogone longifolia*, Fenzl.

Geogr. limits.—*N.* Siberia: R. Irtysch. *E.* Lake Baïkal.
S. Transylvanian Alps. *W.* Croatia.

Iconogr.—*Ic. Taurin.* xiv. t. 73. f. 3; *Reichb. Ic. Fl. Germ. Helv.* 4934 (Pettera graminifolia).

105. A. LONGIFOLIA, *Bieb. Fl. Taur. Cauc.* i. p. 345, iii. p. 308 (1808); *Ledeb. Fl. Rossica*, i. p. 362 (excl. var. β).

The type-specimens of this plant are in Willd. herb. no. 8752 (fol. 4, 5).

Hab. South and Central Russia, and South and Western Siberia.

Iconogr.—*Ledeb. Ic. Pl. Fl. Rossic.* 403.

106. A. ACULEATA, *S. Wats. Bot. King's Exped.* p. 40 (1871); *Robinson, in Proc. Amer. Acad.* xxix. p. 294 (1894).

Glabra, glauca, 15 centim. Folia subulata rigida aculeata Cymæ pauciflora. Sepala late ovata acuta. Petala elliptico-lanceolata, emarginata vel eroso-dentata, 1½–2-plo calyce longiora.

A plant distinguishable from those allied to it by the character of the margin of the petals. The sepals are variable, and become more acute in the southern form, which is more difficult to distinguish from those varieties of *A. congesta* which have an open inflorescence.

Geogr. area. W. United States, from Oregon to Arizona.

Subsectio 2.

Apud multa folia, axillæ fasciculos foliorum adentes.

107. A. DRYPIDEA, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 49 (1842); *Fl. Orient.* i. p. 696.

Hab. Prov. of Marasch, between the Eastern Taurus and the R. Euphrates; occurs up to 2700 metres on rocky places.

108. A. Ledebouriana, *Fenzl, in Russegg. Reise*, ii. p. 931 (1841–42); *Boiss. Fl. Orient.* i. p. 696.

β. glutinosa, *Boiss.* (sp.) *in Ann. Sc. Nat.* 1854, p. 247, t. 2; *et Fl. Orient.* i. p. 697.

Rami superne glutinosi.

γ. parviflora, *Boiss. Fl. Orient.* i. p. 697.

Cyma magis effusa. Pedicelli calyce 4–7-plo longiores. Calyx minor, sepalis magis acutis.

Geogr. limits.—N. & E. Russian Armenia.
S. Mt. Taurus, in Cilicia.
W. Angora, in prov. of Anatolia.

Iconogr.—*Boiss. in Ann. Sc. Nat.* 1854, p. 247, t. 2; et *in Tchihat. Asie Min. Bot.* iii. t. 14 (1862) (var. β).

Syn. *A. trichotoma* (non Royle), Boiss. Diagn. Pl. Or. nov. Ser. II. v. p. 60 (var. γ).

109. A. acerosa, *Boiss. & Heldr. exsicc.* 1847, *et Boiss. Diagn. Pl. Or. nov.* Ser. I. viii. p. 103 (1849); *Fl. Orient.* i. p. 697.

Caudices prostrati. Rami pumili breves glabri. Folia ramorum sterilium stricta penicilliformia, ramorum floriferorum remota, omnia brevia rigida triquetra setaceo-subulata aristata margine scabra, viridia vel basi rubella. Cymæ confertim et corymbose 5–9-floræ; floribus in pedicellis glutinosis suffultis. Calyx ovatus; sepala valde glutinoso-hirsuta oblonga setaceo-acuminata subacerosa late scarioso-marginata, dorso convexo-carinata. Petala oblonga obtusa, calyce $\frac{1}{3}$ parte longiora.

Facies et folia præcedentis, differt cymâ simplici, pedicellis brevibus, sepalis acerosis, flore duplo majore.

β. glabra, *Boiss. Fl. Orient.* i. p. 697.

Calyx et pedicelli glabri. Pedicelli alares ad medium bracteati, pedicellus dichotomialis basi bracteatus (ut in typo).

Geogr. limits.—N. & E. Kharput, in prov. of Diarbekir (*Sintenis*, It. Orientale, 1889, no. 538).
S. Mt. Ak-dagh, in S. Anatolia.
W. Mt. Bereket-dagh, in Anatolia.

In fixing the limits of these Oriental species, one has to remember that there are five mountains in Asia Minor which bear the name of Ak-dagh—one in prov. of Erzeroum, one in prov. of Van, one in prov. of Karamania, and two in prov. of Anatolia (one near Kiutayeh and the other above Elmalu). Specimens were first collected between Konieh and the lake of Bey-sheyr, in the prov. of Karamania (1845).

110. A. Lessertiana, *Fenzl, in Russegg. Reise*, ii. p. 932 (1841–42); *Boiss. Fl. Orient.* i. p. 697.

β. minor, *Boiss. Fl. Orient.* i. p. 698.

Folia 10–13 mm. longa; scapi 2½–7 centim. a basi sæpe dichotomi vel uniflori.

Geogr. range. Persia (up to 3850 metres).

Syn. *A. persica*, Boiss. Diagn. Pl. Or. nov. Ser. I. i. p. 49. (This plant was described a few months after Fenzl's species.)
Alsine pungens, Stapf, Bot. Polak. Exped. 1882.

111. A. tetrasticha, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 50 (1842); *Fl. Orient.* i. p. 698.

Geogr. range. Persia.

Subgenus II. EREMOGONEASTRUM.

Sectio i.

Calyx basi haud indurascens. Flores solitarii, raro cymosi.

112. A. Bourgæi, *Hemsl. Diagn. Pl. Nov.* ii. p. 21 (1879); *Biol. Centr.-Amer., Bot.* i. p. 70.

Parcissime pilosula. Rami 7–30 centim., debiles procumbentes angulati. Folia parva distantia lineari-oblonga sessilia basique subamplexicaulia, obtusa vel subacuta, margine ciliolata. Flores solitarii axillares pedicellati albi. Sepala glabra ovato-oblonga vel fere elliptica, margine diaphano-scariosa. Petala oblonga, sepalis duplo longiora. Disci glandulæ aurantiacæ. Ovarium globosum. Semina reniformia cinnamomea nitida punctulata.

Hab. Mexico.

113. A. festucoides, *Benth. in Royle, Illustr. Bot. Himal.* p. 81, t. 21. f. 3 (1839); *Hook. f. Fl. Brit. Ind.* i. p. 236 (1874).

Geogr. range.—West alpine Himalaya.

N. Kunawar in Kashmir. *E.* R. Karnali in W. Tibet.
S. Pindasi in Kumaon. *W.* Lahul, in the Punjaub.

Iconogr.—*Royle, l. c.*; *Klotzsch in Bot. Ergeb. Waldem. Reise*, p. 142, t. 27 (A. Gulielmi-Waldemarii).

Syn. *A. Falconeri*, Edgew. (no. 257 in Herb. E. Ind. Co.).
A. muralis, Edgew. *ex* J. F. Watson, Pl. Kumaon (1874).
A. pungens (non Clem.), Jacquem. (no. 894 in Herb. Paris.).
A. Roylei, Benth. (in Herb. Kew.), et Garcke *ex* Klotzsch.

114. A. MONTICOLA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 238 (1874); *Jacks. Ind. Kew.* i. p. 180.

Glabra, dense cæspitosa omnino squarrosa, basi lignosa. Rami dense foliati. Folia basi scarioso-vaginantia, rigida brevia patenti-recurva subulata, apice aciculata, margine incrassata ciliolata, nitida, nervo mediano valde prominente floralia majuscula lanceolato-subulata scariosa. Flores solitarii sessiles. Calyx basi truncatus; sepala ovato-lanceolata acuminata valde trinervia, ultra nervos late scariosa. Petala late ovata, sepalis longiora, basi breviter unguiculata, apice rotundata, alba. Capsula globosa.

Forms squarrose green patches, on which the large white flowers are conspicuous.

Hab. Tibetan region of Sikkim Himalaya, at 4800 metres; but does not occur in British India.

115. A. KANSUENSIS, *Maxim. in Bull. Acad. Pétersb.* xxvi. p. 428 (1880); *Mél. Biol.* x. p. 579; *Fl. Tangutica*, p. 86, t. 14 (1889).

Densissime pulvinata, glabra. Caudex lignosus, polycephalus. Cauliculi 24 mm. simplices. Folia subtriquetra pungentia, turionum basi latiora scariosa scabro-serrulata, ramulorum floriferorum ad apicem fere scariosa, supremis bractealibus decrescentibus. Pedicelli pilosi. Calyx basi rotundatus, haud incrassatus; sepala lanceolata obsolete subtrinervia late hyalino-marginata, acuta vel sæpius acuminata, apice recta. Petala obovata, calyce occultata. Ovarium globosum.

Hinc *A. monticolæ* persimilis, differt autem hæc foliis bractealibus tantum 4 dilatatis, flore sessili, pedicello glabro, petalis ex ungue distincto ovatis sepala distincte trinervia superantibus, ovario ovoideo neque globoso, flore paullo minore.

Hab. China: prov. of Szetschuan (*Potanin*, 1885), above Tachien-lu on the confines of Tibet (*A. E. Pratt*, 1890). Tibet: Amdo in prov. of Tangut, and prov. of Kansu (*Przewalski*, 1872).

Iconogr.—*Maxim. Fl. Tangutica, l. c.*

Sectio ii.

Calyx basi induratus. Flores cymosi vel solitarii.

Subsectio 1.—Caules floriferi simplices, remote foliati; turiones foliis angustis dense comati multum breviores. Flores cymosi. Petala sæpius sepalis longiora.

116. A. SCARIOSA, *Boiss. in Tchihat. Asie Min. Bot.* i. p. 234 (1860); *Fl. Orient.* i. p. 692.

Basi indurata, valde cæspitosa. Caudex crassus lignosus,

turiones caulesque floriferos edens. Caules 15 centim. Folia brevia stricta setaceo-subtriquetra scabrida, basi membranaceo-dilatata, apice obliquiter mucronata. Inflorescentia cymoso-corymbosa 6–15 florum; cymis strictis glandulosis, bracteis lanceolatis scariosis. Sepala lanceolata acuta, dorso convexa, præter basin subvirentem omnino scarioso-alba. Petala oblongo-linearia basi subattenuata, calyce breviora. Glandulæ sub-spathulatæ.

Hab. Turkish Armenia: between Gumuchkhane and Kerekli in prov. of Trebizond.

117. A. GRAMINEA, *C. A. Mey. Verz. Pfl. Cauc.* p. 220 (1831); *Boiss. Fl. Orient.* i. p. 692.

The leaves of the barren shoots are about 15 centim. long.

Geogr. limits.—*N.* Russian Armenia: Mt. Kara-bagh (*Szowits*, no. 322, ex. Herb. hort. Petropolit.).

S. & E. Tatuni, in prov. of Talysch, at 1300 metres above the Caspian Sea (1836).

W. Persian Armenia: Mt. Kara-dagh, in the district of Khoi.

SYN. *Eremogone graminea*, C. A. Mey. *ex* Fisch. et Mey. Ind. Sem. hort. Petropol. i. p. 7.

118. A. BLEPHAROPHYLLA, *Boiss. Fl. Orient.* i. p. 693 (1867); *Jacks. Ind. Kew.* i. p. 178.

Caules 15 centim., dense foliosi, cum turionibus vaginis carinatis ciliatis foliorum vetustorum plus minus vestiti. Folia turionum brevia setacea flexuosa, margine serrulato-scabra vel ciliata incrassata albo-cartilaginea, caulina plana trinervia setaceo-acuminata. Panicula glandulosa breviter thyrsoidea conferta. Sepala ovato-oblonga obtusa glabra late viridia. Petala oblongo-linearia, sepalis duplo longiora. Glandulæ breves lineares, apice subincrassatæ.

β. breviflora, *mihi.*

SYN. *A. graminea*, var. *parviflora*, Fenzl, in Ledeb. Fl. Rossica, i. p. 362.

A. Steveniana, Boiss. Fl. Orient. i. p. 692 (var. *β*).

Folia facie superiore vix concava, margine haud ciliata. Sepala oblonga, minus obtusa. Petala breviora.

Hab. Armenia, from Lake Gök-tchaï in Russian Armenia to Mt. Bingöl-dagh in Turkish Armenia.

In Herb. Kew. are specimens collected by Calvert and Zohrab in 1867, labelled "Gypsophila succulina." These specimens are

referred by Dr. Stapf to *A. blepharophylla.* I know of no species of *Gypsophila* published under this name, and have seen no other specimens of the above species.

119. A. Griffithii, *Boiss. Diagn. Pl. Or. nov.* Ser. II. i. p. 89 (1853) ; *Fl. Orient.* i. p. 697.

Basi suffruticosa, glabra vel parce breviterque puberulo-viscidula. Rami floriferi 4–5 centim., erecti sæpius 1–3-flori viscidi. Folia brevia setaceo-subulata pungenti-rigida apicem versus patenti-recurvata uninervia ciliolata, eorum axillis fasciculos foliorum edentibus. Bracteæ triangulares acuminatæ breves concave ovato-subulatæ. Calyx breviter ovatus, basi rotundatus; sepala coriacea glandulosa fere æqualia carinata oblonga breviter attenuato-mucronata intus concava basi obscure trinervia late hyalino-marginata. Petala obovata, calyce sesqui-longiora. Capsula globosa vel late ovoidea, inclusa.

Accedit ad *A. Lessertianam* var. *minorem*, a quâ differt foliis magis tenuibus, ramis floriferis nec omnino scapiformibus, etiam sepalis mucronatis.

Boissier gives only a single locality for this species, Mt. Koh-i-Baba in Affghanistan, at an elevation of 4000 metres. It is now known to be a widely spread species, being found in several localities in West Central Asia.

Geogr. limits.—N. Russian Turkestan : Lake of Kul-i-Kalan (*Regel*, exs. It. Turkestan., 1882 ; *Komarow*, Mat. Fl. Turkestan [1896]).

S. & E. Kashmir: Dras Valley in Little Tibet.

W. Affghanistan : Kurrum Valley, Mt. Koh-i-Baba.

120. A. armeniaca, *Boiss. Diagn. Pl. Or. nov.* Ser. I. i. p. 48 (1842); *Fl. Orient.* i. p. 691.

A plant with the flowering stems rising about 15 centim. above the tuft, with fasciculate flowers not closely aggregated.

Hab. Turkish Armenia: dry hills round Baïburt in the prov. of Erzeroum, and rocky slopes at Teke near Gumuchkhane in the prov. of Trebizond (*Sintensis*, It. Orientale, 1894, no. 6113).

Subsectio 2.—Caules breves, dense foliosi, simplices vel ramulosi. Flores solitarii. Petala semper sepalis longiora.

121. A. polytrichoides, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 237 (1874).

Musciformis, densissime cæspitosa, cæspitibus hemisphæricis,

glabra. Radix prælonga robusta lignosa dura. Caules teretes, 2–10 centim. Folia subulata recurvata rigida pungentia basi late scarioso-vaginantia subsquarrosa, facie canaliculata, dorso convexa, margine incrassata obscure ciliata, præcipue ad basin versus, nitida. Flores minuti, breviter pedicellati, bracteis elongatis cuspidato-ovatis ad dimidium calycem attingentibus instructi. Calyx basi rotundatus; sepala elliptica obtusa obsolete trinervia, margine haud scariosa. Petala late obovata, apice rotundata. Capsula ovoidea.

β. perlevis, *Williams*.

Syn. *A. musciformis* [*non* Triana et Planch.], Edgew. *l. c.*

Sepala oblongo-lanceolata fere acuta membranaceo-marginata.

In his 'Fl. Tangutica,' Maximowicz points out that in the specimens of *A. musciformis* collected by Capt. Strachey, which he carefully examined, the flowers are white and are not sessile but shortly pedicellate, which makes the plant agree still more with typical *A. polytrichoides*. He also notes that the bracts are elongated, ovate and cuspidate, reaching to half length of the calyx. If *A. musciformis* were not reduced to this species, the name would have to be changed, as there is an earlier use of the name for a S. American species. Specimens have been collected at an altitude of 5900 metres, which is higher than that of any other species of *Arenaria*. It forms matted hard tufts, tougher than those of *A. pulvinata*; and there is a good specimen mounted in a glass case in the Kew Museum.

Hab. Tibet: Balch, Karakoram and the Parang Passes, south shore of Lake Mang-isa-Tso in N.W. Tibet (*Capt. Deasy's* Exped. to Tibet, 1896–97, no. 813); alpine region of Sikkim Himalaya on the Tibetan side. China: Ba-tang on the river Di-chu, and at Ta-chien-lu on the river Tung, in the prov. of Sze-chuen (*Kanitz*, Bot. Centr. Asiat. Exped. Szechenyi, in Math. Naturwissensch. Ber. Ung. iii. [1886]).

122. A. pulvinata, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 238 (1874); *Jacks. Ind. Kew.* i. p. 180.

Densissime et pulvinatim cæspitosa, cæspitibus subglobosis compactis, pallide virens, subsquarrosa. Folia plana brevia subulato-recurvata mucronata, basi semi-tereti scarioso-vaginante, margine hispido-ciliata. Flores sessiles non bracteati. Calyx basi rotundatus; sepala ovato-lanceolata subacuta, nervis 3 approximatis, margine cartilagineo-scariosa. Petala obovata,

sepalis duplo longiora. Capsula ovoidea polysperma. Semina obovato-reniformia subglabra.

Hab. On the Tibet side of the Sikkim Himalaya, at 4500-5400 metres.

Of the species described in the 'Fl. of British India,' 21 are to be referred to *Arenaria* as defined in this Revision. Of these 21, however, six do not occur in India at all, but in Tibet, viz., *A. globiflora*, *A. oreophila*, *A. pulvinata*, *A. monticola*, *A. polytrichoides*, and *A. musciformis*. The last two are here united in one species. To these are now added three new Indian species—*A. ferruginea*, *A. kumaonensis*, and *A. tenella*.

A. pulvinata forms small subglobose densely compacted squarrose tufts: the stems bearing flowers only 6 mm. in diameter, not subtended by enlarged upper leaves in the form of bracts as in *A. monticola*. Of the other species of *Arenaria* described in the 'Fl. of British India,' the majority occur in the native and feudatory states, and cannot be rightly reckoned among *British* Indian species. These only will include the following:—*A. festucoides*, *A. serpyllifolia*, *A. nilghirensis*, *A. glanduligera*, *A. ciliolata*, *A. holosteoides*, *A. glandulosa*.

123. A. GLOBIFLORA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 239 (1874); *Fenzl, in Ann. Wien. Mus.* i. p. 63, t. 71 (1836) (Dolophragma globiflorum).

Don describes the flowers as rose-coloured, which the specimens do not bear out, and the stigmas as capitate, which is not the case, neither are remains of septa to be found in the capsules.

Hab. Gosaï-Than in Tibet, in the alpine region of the Nepal Himalaya.

Iconogr.—*Fenzl, l. c.*

SYN. *Cherleria grandiflora*, D. Don, Prodr. Fl. Nepal. p. 214.
Dolophragma globiflorum, Fenzl, in Ann. Wien. Mus. i. p. 63, t. 71 (1836).

124. A. DENSISSIMA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 239 (1874); *Fenzl, in Ann. Wien. Mus.* i. p. 63, t. 71 (1836) (Dolophragma juniperinum).

The locality given in the Flora mentioned above is Gosaï-Than, in the Nepal Himalaya; but this locality is neither in British India, nor in Nepal, but in Tibet. It was first recorded for India by Dr. George Watt in 1881 (exs. no. 5426); and was collected at the summit of Mt. Surkia-La in the Sikkim Hima-

laya, at 4150 metres (*Herb. Kew.*); also by Mr. C. B. Clarke above the Yak Pass at 5100 metres.

Iconogr.—*Ann. Wien. Mus.* i. p. 63, t. 71 (1836).

125. A. KUMAONENSIS, *Maxim. Fl. Tangutica*, i. p. 86 (1889).

Dense pulvinata. Folia e latiore scariosâ basi subulata triquetra pungentia glabra; ramulorum floriferorum latiora breviora fere tota scariosa, suprema bracteiformia decrescentia, omnia ciliata. Pedicelli viscido-villosi. Sepala uninervia hyalino-marginata. Petala alba elliptica obtusa, petalis parum longiora. Antheræ atræ. Ovarium globosum. Capsula inclusa, oblongo-ovata. Semina margine dense cristato-tuberculata, disco lævia.

A præcedenti longe distat aspectu, characteribus autem ad dignoscendum liquida: in prov. Tibeticâ haud occurrens.

Hab. Himalayas: District of Kumaon, in the North-West Provinces (1884).

126. A. TETRAGYNA, *Willd. herb.* no. 8748, et ex *Schlecht. Gesellsch. naturf. Fr. Berl. Magaz.* vii. p. 201 (1813); *Rohrb. in Linnæa*, xxxvii. p. 256 (1871–72).

α. imbricata, *Fenzl*, ex *Rohrb. in Linnæa*, xxxvii. p. 256 (1871–72).

Caulis ramuli breves conferti, internodiis abbreviatis, glaberrimi. Folia valde approximata, subacuta, 6–8 mm. Flores breviter pedicellati, pedicellis glabris calyce sesquilongioribus.

Hab. The Andes of Ecuador: Mt. Antisana, at 4200–4500 metres.

β. laxa, *Fenzl*, l. c. p. 257.

Caules plus minus laxi diffusi, internodiis elongatis. Folia remota, nunc acutiuscula nunc obtusiuscula, longiora, usque ad 10 mm. Flores sepalis paullum longius pedicellati.

Lusus 1:—Caules et pedicelli glaberrimi.

Hab. Mexico, Peru, and Chile.

Lusus 2:—Caules unifariam pilis brevibus vestiti, pedicelli florum dense pilosi, rarius in eodem specimine glabrescentes.

SYN. *A. inconspicua*, Poepp. Coll. Pl. Chil. iii. p. 127, Diar. p. 746.
A. cryptopetala, Kunze, Syn. Pl. Amer. Austr. MSS.

Hab. Chile.

Herba polymorpha est, et *var.* β lusu altero ad *A. palustrem* accedit, a quâ tamen habitu multo laxiore, glandulis conspicuis, capsulæ formâ seminibusque satis differt.

Geogr. range.—N. & W. Mexico.

S. & E. Chile: Volcano of Antuco, in the Andes of Biobio.

Iconogr.—*H. B. et K. Nov. Gen. et Spec.* vi. p. 25, t. 517.

Subgenus III. PENTADENARIA.

Sectio i. GLOMERIFLORÆ.

Flores subsessiles, in cymis capitato-aggregatis vel glomerato-fasciculatis; flore centrali sæpius ebracteato. Glandulæ emarginatæ.

127. A. PRZEWALSKII, *Maxim. in Bull. Acad. Pétersb.* xxvi. p. 428 (1880); *Mél. Biol.* x. p. 578; *Hemsl. Ind. Fl. Sinens., in Journ. Linn. Soc.* xxiii. p. 70.

Cæspitosa, polycephala. Caudices adscendentes, foliis emortuis tortis mollibus tecti polyphylli. Folia margine scabra, plana, crasse cartilagineo-marginata, uninervia; turionum folia elongata linearia obtusa, caulina lanceolato-linearia magis obtusa. Cauliculi glanduloso-pilosi. Cyma contracta triflora; flores alares infra basin bibracteolati. Calyx glanduloso-pilosus campanulatus; sepala emarginato-biloba. Petala unguiculata obovata, apice truncata, sepalis parum- vel sesquilongiora.

A. capillaris var. *formosa*, Fisch., huic persimilis, pluribus notis differt: folia omnia triquetra subulato-filiformia pungentia, pedicelli infra medium (nec ad apicem) bracteati et plures flores ibi ferentes, sepala haud emarginata, petala exunguiculata ovali-oblonga, postremum filamenta subulata.

Hab. China: prov. of Kansu (*Przewalski*, 1872).

Iconogr.—*Maxim. Fl. Tangutica*, t. 15 (1889).

128. A. DIANTHOIDES, *Smith, Ic. Pl. ined.* p. 16, t. 16 (1789); *Boiss. Fl. Orient.* i. p. 691.

Distinguished from other species by its very long basal leaves, and by its petals like those of a species of *Dianthus*.

Geogr. limits.—N. Russian Armenia: near Ervain.

S. Persian Armenia: mountains of prov. of Aderbidjan.

E. Prov. of Talysch, in Trans-Caucasia, at 2150 metres.

W. Turkish Armenia: Mt. Tech-dagh and Mt. Bingöl-dagh, in prov. of Erzeroum (Tournefort's specimens).

Iconogr.—*Smith, l. c.*

Sectio ii. RARIFLORÆ.

Flores pedicellati, in cymas simplices aut compositas interdum depauperatas, vel per thyrsum brachiatum paniculæ- vel corymbiformem, dispositi, pedicellis calyci æquilongis vel longioribus suffulti; bracteæ ochreaceæ subvaginantes scariosæ. Glandulæ integerrimæ.

Subsectio 1.—Folia lineari-setacea vel graminea, imprimis turionum. Semina lævia.

a. Sepala, præter nervum dorsalem viridem in mucronem haud excurrentem, flava vel albida.

129. A. RIGIDA, *Bieb. Fl. Taur. Cauc.* i. p. 346 (1808), iii. p. 309; *Ledeb. Fl. Rossica*, i. p. 361.

Geogr. limits.—N. S. Russia: gov. of Podolia, between Kosy and Jaorlik.

S. Roumania: prov. of Dobrudscha (ex *Kanitz*, Pl. Roman. suppl. p. 185).

E. S. Russia: gov. of Ekaterinoslav, near Paulovgrad (the original specimens).

W. Roumania: prov. of Moldavia (ex *Nym.* Consp. Fl. Eur. p. 113).

SYN. *A. androsacea*, Fisch. *ex* Cand. Prodr. i. p. 402.
A. Holostea (*non* Bieb.), Beaupr. *ex* Cand. Prodr. i. p. 402.
Eremogone rigida, Fenzl, Verbreit. Alsin. t. ad p. 46.

130. A. GRAMINIFOLIA, *Schrad. Hort. Götting.* i. p. 5, t. 5 (1809); *Ledeb. Fl. Rossica*, i. p. 363 (excl. var. *α*).

α. glabra, *mihi.*

(=*β.* grandiflora, *Ledeb. Fl. Rossica*, i. p. 364.)

Cymæ glaberrimæ, frequentius ternæ corymbosæ, quam plures thyrsoideo-dispositæ, pedicellis alaribus inferioribus plus 12 mm. usque 48 mm. (inde patentioribus magisque sparsifloris). Calyx post anthesin 4–6 mm. longus.

β. pubescens, *Ledeb. Fl. Rossica*, i. p. 364.

Cymæ glanduloso-puberulæ ternæ, rarius plures vel solitariæ, plerumque scaberrimæ.

Geogr. limits.—N. E. Siberia: riv. Vilini at Vilinisk (*Kruhse*).

E. Kamtschatka (*Eschscholtz*).

W. Lyck in Prussia.

S. S. Hungary: the Banat.

Iconogr.—*Schrad. l. c.*

SYN. *A. Biebersteinii*, Schlecht. in Gesellsch. Naturf. Fr. Berl. Mag. vii. p. 202 (1813) (var. β).
A. filifolia, Bieb. Fl. Taur. Cauc. i. p. 344 (var. β).
Eremogone graminifolia, Fenzl, Verbreit. Alsin. p. 37.
E. micrantha, Schur, Enum. Pl. Transsilv. p. 912.
A. ucranica, Spreng in Ersch. *sec.* Steud. Nomencl. ed. 2, i. pp. 124, 127.

131. A. KORINIANA, *Fisch.* ex *Ledeb. Fl. Rossica*, i. p. 363 (1842); *Jacks. Ind. Kew.* i. p. 179.

Hab. East Russia, desert of Orenburg; S. Siberia, Mt. Alatau in Soungaria.

132. A. OREOPHILA, *Hook. f. Fl. Brit. Ind.* i. p. 238 (1874); *Jacks. Ind. Kew.* i. p. 180.

Dense cæspitosa, cæspitibus parvis subglobosis valde compactis, fere glabra. Caules simplices. Folia lineari-subulata recurvata e basi latâ vaginante semi-teretia acuta glabra, non carinata. Flores solitarii breviter pedicellati, pedicellis puberulis calyci æquilongis. Calyx basi rotundatus incrassato-induratus, sepala orbicularia concava subenervia coriacea ciliolata. Petala angusta, sepala duplo excedentia, obovato-spathulata apice rotundata. Capsula late ovoidea, coriacea. Semina pallida subauriformia.

The specimens collected by Sir J. D. Hooker have been so well examined that little more can be made out of them, nor can all the characters given be satisfactorily verified. Though included in the flora, the plant does not occur in British India, but was collected on the Tibetan side of the Himalayas at an elevation of 5350 metres. This is interesting as being the highest altitude at which a species of *Arenaria* had been found until last year, though Mr. C. B. Clarke had collected specimens of *A. densissima* at 5100 metres.

Hab. Tibetan Himalayas, in the Sikkim region.

133. A. FERRUGINEA, *Duthie, ined. in Pl. Kumaon*, no. 2762 (1884); in Herb. Mus. Brit.

Laxe cæspitosa. Caules multum ramosi retrorsum pubescentes, inferne angulati, ramis teretibus. Folia lineari-subulata rigida patenti-recurva canaliculata acuminata, uninervia vel obsolete 3-nervia. Flores in cymas compositas trichotomas latas plus minus diffusas dispositi; pedicellis alaribus ad medium bracteatis. Bracteæ foliis similes sed minores. Calyx

incrassato-induratus; sepala lanceolata acuminata uninervia, late scarioso-marginata, apice recurva. Petala ovalia acuta unguiculata, sepalis breviora. Glandulæ quadratæ. Capsula ovoideo-globosa coriacea, valvis 3 bidentatis dehiscens, apice attenuata obtusa. Semina pauca compressa pallida subauriformia.

The quadrate glands at the base of 5 stamens determine the systematic position of the plant in the genus. Among Himalayan species, it is nearest to *A. oreophila*, but it is readily distinguished from this, as from the other four species in this small group, by the petals being shorter than the sepals and by its habit.

Hab. Kumaon: Kali Valley, on rocks near Byans, at 2800–3000 metres.

134. A. Tschuktschorum, *Regel, in Bull. Soc. Nat. Mosc.* xxxv. i. p. 254 (1862), t. 9. f. 1.

Omnino glabra, glaucescens. Caudex crassus lignosus. Caules floriferi 10–20 centim., foliorum fere denudati, stricti vel flexuoso- vel subgeniculato-adscendentes, sæpe superne purpurascentes, apice corymbum 3-pluriflorum umbelliformem simplicem vel ramosum gerentes. Folia subulata canaliculata rigida, nervo crasso percursa, in mucronem pungentem attenuata, præcipue basin versus margine minute denticulata, basi ipsâ brevissime connata, caulina remota. Corymbus 3-pluriflorus; pedicellis primariis supra medium vel basin versus bibracteatis; bracteæ lanceolato-lineares acuminatæ. Calyx basi rotundatus; sepala elliptica vel elliptico-oblonga obtusa, margine late hyalina. Petala obovata, calycem plus duplo superantia. Glandulæ quadratæ aurantiacæ. Capsula subinclusa. Semina compressa.

Hab. Land of the Tschuktschees: along the river Phillipow, and near the town of Nischni-Kalinsk.

Described from authentic specimens in Herb. Kew. ex Herb. Hort. Petropolit. The character of the glands and of the seeds, which determines its position in the genus, is not mentioned by Regel in his description, nor indicated in the figure of the plant cited below.

Iconogr.—*Regel, Pl. Raddeanæ, l. c.*

β. Sepala, nervo dorsali lato in mucronem herbaceum recurvo-patulum excurrente, picta vel subherbacea.

135. A. gypsophiloides, *Linn. Mant. Plant.* i. p. 71 (1767); *Ledeb. Fl. Rossica*, i. p. 365.

α. glabra, *Ledeb. Fl. Rossica*, i. p. 365.

Lusus 2 :—Calyx 2½–3 mm.; sepala sæpe longe acuminata.

SYN. *A. gypsophiloides* var. *parviflora,* Boiss. Fl. Orient. i. p. 694.

β. viscosa, *Ledeb. Fl. Rossica*, i. p. 365.

This species is the plant described by Tournefort as "Alsine orientalis Caryophylli folio, flore parvo albo." It is of the habit of a *Gypsophila*.

Geogr. limits.—*N.* Russian Armenia : Lake Gök-tchai.

S. & E. N. Persia ; at the base of Mt. Demavend, in the Elburz range.

W. Turkish Kurdistan: prov. of Diarbekir, between Diarbekir and Suwerek. (It was in this neighbourhood that Tournefort collected his specimens.)

SYN. *A. cucubaloides* (*non* Smith), C. A. Mey. Verz. Pfl. Cauc. p. 220.
A. dianthoides, Hort. *ex* Ledeb. Fl. Ross. i. p. 365.
Eremogone gypsophiloides, Fenzl, Verbreit. Alsin. t. ad p. 57.

136. A. URSINA, *Robinson, in Proc. Amer. Acad.* xxix. p. 294 (1894); *Gray & Robinson, Syn. Fl. N. Amer.* i. p. 240 (1897).

Radix crassa lignosa. Tota glauca. Caudex dense multiceps. Turiones compacte fasciculati vel rosulati. Caules florigeri pauci erecti ramosi teneri tenuiter glanduloso-pubescentes 4–7 centim. Folia turionum lineari-filiformia albo-punctulata apiculata glanduloso-ciliolata perbrevia, caulina pauca remota rigidiora. Sepala enervia late ovata nec acuta. Petala alba oblonga vix emarginata. Capsula calyce multum longior. Semina circiter 6.

This species has much the habit of *A. compacta*, but much more obtuse sepals; it is very nearly related to *A. capillaris*, but differs in its condensed habit and in a waxy punctuation of the leaves. Mr. Robinson subsequently reduces his plant to a variety of *A. capillaris*, but none of the many forms of *A. capillaris* have glaucous leaves and emarginate petals.

Hab. California: dry hills in Bear Valley, San Bernardino Mtns.

137. A. CARICIFOLIA, *Boiss. in Tchihat. Pl. exsicc.* 1858, no. 943, *et Asie Min. Bot.* i. p. 235 (1860); *Fl. Orient.* i. p. 694.

Glabra. Caudex lignosus. Caules 45 centim., robusti adscendentes cum turionibus basi vaginato-squamati, crassi teretes ad nodos conspicue incrassati, superne paniculati multiflori.

Folia prælonga linearia subcanaliculata setaceo-acuminata plurinervia, margine cartilagineo-incrassata ciliolata-scabra; bracteæ lanceolatæ. Panicula thyrsoidea brevis lata multiflora. Sepala coriacea oblongo-lanceolata obtusa carinata viridia superne anguste rubello-membranacea. Petala oblongo-linearia longe attenuata in unguem, sepala 3-plo excedentia. Glandulæ quadratæ. Capsula ovata.

A species very distinct in the very long basal leaves like those of a species of *Carex*: in the specimens I have found them as much as 32 centim. long. It further differs from *A. gypsophiloides* in the flower being twice as large with more obtuse sepals.

Hab. South Armenia, between the villages of Avzapert and Uzunbazar (not marked in maps).

138. A. Roborowskii, *Maxim. Fl. Tangutica*, p. 87, t. 29 (1889).

Densissime pulvinata. Cæspites orbiculares 12 centim. lati, radici fusiformi longissimæ insidentes. Cauliculi densissime conferti teretes supra basin aggregato-ramosi, basi foliis emarcidis dense obvallati, apice virides polyphylli. Folia cauliculi infima sub anthesi emarcida, in cauliculo sterili tamen virentia breviter in vaginam connata, sequentia sensim breviora et in vaginam altius connata, trinervia incrassato-marginata, omnia mucrone pungente distincto terminata, dorso carinata, margine crebre ciliata; folia ramulorum florigerorum breviora, suprema bractealia lanceolato-linearia. Calyx basi incrassatus quasi gibbosus; sepala lanceolata uni-subtrinervia. Petala elliptica acuta, calyce breviora. Stamina corollâ breviora; antheræ ochroleucæ. Glandulæ ovoideæ turgidæ. Ovarium globosum; styli recurvo-adpressi. Ovula numerosa.

Affinis *A. densissimæ*, quæ tamen differt foliis recurvatis omnino glabris, flore terminali et axillari breviter pedicellato, sepalis ovatis quam petala spathulato-linearia duplo brevioribus, staminibus corollam superantibus, stylis erectis.

Description verified from authentic specimens in Herb. Kew.

Hab. W. Tibet: R. Yang-tze (1884).

Iconogr.—*Maxim. l. c.*

139. A. CAPILLARIS, *Poir. Encycl. Méth.* vi. p. 380 (1804); *Ledeb. Fl. Rossica,* i. p. 367 (*cum* A. formosa *et* A. Meyeri).

Grex a. Folia subulato-setacea vel subcapillaria, rigida, etiam in statu sicco stricta.

α. typica (= A. capillaris *Poir. α, Regel et Tiling. Fl. Ajan.* p. 4, n. 63).

Glabra, glauca. Folia 25–50 mm. vel rarius longiora, margine glabra vel ciliolata. Caules 7–15 centim., uniflori vel plerumque cymâ triflorâ rarius 5-florâ terminati. Pedicelli graciles, deinde 12–35 mm. longi, medio bracteis 2 membranaceis parvis vestiti. Petala alba.

β. airæfolia, *Fisch.* (sp.) *ex DC. Prodr.* i. p. 402.

Cyma sepalaque glanduloso-pubescentia.

Lusus 1, pygmæa, *Regel, Pl. Radd.* p. 368 (1862).—Caules 4–10 centim., 1–3-flori interdum 5-flori, erecti vel adscendentes, basi glabri. Folia 12 mm., glaucescentia, margine plerumque ciliolata. Flores minores, pedicellis calycem paullo-pluries superantibus. Sepala ovato-lanceolata.

Lusus 2, glandulosa, *Regel, l. c.*—Caules 5–8 centim., ad basin glanduloso-pubescentes. Folia 23 mm., glaucescentia, mucronulo recto terminata. Cyma 1–3-flora, dense viscoso-pubescens, pedicellis calycem subæquantibus vel vix eodem duplo longioribus. Petala calyce duplo circiter longiora.

SYN. *A. viscosa,* Fisch. *ex* Cand. Prodr. i. p. 403.

Lusus 3, communis, *Regel, l. c.*—Caules 7–18 centim., basi glabri. Folia 25–40 mm. Cyma 1–7-flora; pedicellis deinde gracilibus, calycem pluries superantibus. Variat floribus majoribus et minoribus: similis formæ typicæ, indumento tamen diversa.

Lusus 4, longifolia, *Regel, l. c.*—Caules 17–20 centim., basi glabri. Folia 70–95 mm., virescentia. Cyma evidentius laxa 5-pluriflora; pedicellis gracilibus, calyce demùm pluries longioribus. Petala ovato-oblonga, calyce duplo longiora.

γ. obtusifolia, *Trautv. Pl. Sibir. bor.* p. 34 (1877).

Glabra, glauca. Folia obtusa, apice subtruncata. Petala alba.

Hab. Between the river Olenek and the river Lena (August, 1875).

Grex b. Folia subulato-capillaria, viva plus minus curvata, emortua omnino persistentia stricta.

δ. kamtschatica, *Regel, Pl. Radd.* p. 372.

Cauliculi 7–20 centim., 1–8-flori. Folia 40–65 mm. Cyma et sepala glanduloso-pubescentia.

Grex c. Folia subulato-capillaria persistentia, viva plus minus curvata vel falcata, emortua flaccida varie contorta et deinde nervo filamentoso terminata.

ε. formosa, *Fisch.* (sp.) *in DC. Prodr.* i. p. 402; *Ledeb. Fl. Rossica*, i. p. 366.

Cyma 1–8-flora, cum sepalis, glanduloso-pubescens.

SYN. *A. nardifolia* var. *glandulosa*, Ledeb. Fl. Altaïc. ii. p. 166.
A. formosa var. *glandulosa*, ex Ledeb. Fl. Rossica, i. p. 366.
A. lychnidea (*non* Bieb.), Turcz. Cat. Baïkal. no. 253.
A. colorata, Turcz. in Herb. Ledeb.
Eremogone formosa, Fenzl, Verbreit. Alsin. p. 37.
E. airæfolia, Fenzl, *ex* Steud. Nomencl. ed. 2, i. p. 566.

Cauliculi 5–15 centim. Folia 25–70 mm., basi dilatata. Pedicelli calycem æquantes vel deinde pluries superantes. Sepala ovata. Petala plerumque late obovata, calycem duplo superantia.

Lusus 1, alpina, *Regel, l. c.*—Caules 50 mm., 1–3-flori. Folia 24 mm. Sepala purpurascentia.

Lusus 2, vulgaris, *Regel, l. c.*—Caules 7–20 centim., 1–8-flori. Folia 45–70 mm. Flores sæpe maximi, speciosi; sepalis plus minus purpurascentibus.

ζ. nardifolia, *Ledeb.* (sp.) *Fl. Altaïc.* ii. p. 166.

SYN. *A. formosa* var. *α. glabra*, Ledeb. Fl. Rossica, i. p. 366.

Varietas glabra. Folia 45–90 mm., margine ciliolata, ceterum glaberrima. Cyma 1–8-flora; flores sepius trichotomo-cymosi; bracteæ cucullatæ ovato-lanceolatæ, basi purpureæ. Petala plerumque lata obovata, calycem duplo superantia.

SYN. *Eremogone nardifolia*, Fenzl, Verbreit. Alsin. p. 37.

η. Meyeri, *Fenzl* (sp.) *in Ledeb. Fl. Rossica*, i. p. 368; *Maxim. Pl. Mongol.* p. 98 (1889).

Varietas nana glanduloso-puberula, pulvinato-cæspitans. Turiones elongati (nec ut in type abbreviatæ), totâ longitudine foliis emortuis imbricato-vaginati. Folia plerumque stellatim patentia. Cyma 3–10-flora corymbiformis. Sepala longe vel breviter mucronata. Petala cuneato-oblonga. Sec. Ledebour, hæc planta transitum ad sectionis *Euthaliæ* species foliis acerosis molitur, turionum autem foliis vegetis, minora axillaria fasciculata nunquam alentibus recedens.

Hab. Soungaria, N. Mongolia, and E. Siberia.

The grouping of the various forms of this polymorphous and very variable species is based upon E. von Regel's detailed examination of many specimens. This botanist, however, includes *A. lychnidea*, Bieb., in the species, which certainly does not belong to this subgenus, as the disk is not broken up into distinct glands: whereas, in *A. capillaris*, five short truncate glands are readily distinguishable at the base of the stamens. In the subdivision of the species as followed out here there are seven varieties which are associated into three 'greges' (or subspecies, as some would prefer perhaps to call them). Forms of lower grade in the discrimination of minor characters are united under some of the varieties. It is extremely difficult in a widely distributed and remarkably variable species such as this is to assess at their right value the grades of deviation from the type, even in a series of specimens from a limited area. Everyone who examines a series of such specimens is likely to form diverse views as to the value and importance of these deviations from the type, and would group these puzzling and inconstant forms differently, and probably as unsatisfactorily. As Ledebour points out, typical *A. capillaris*, which is widely distributed in Siberia, is a glabrous plant with short barren shoots and rigid glaucous leaves, with the flowers usually in trifloral cymes. This form is comparatively rare in N. America, where var. ε. *formosa*, Fisch., is the more common form, in which the leaves are curved or falcate, and the stem and inflorescence invested with a glandular pubescence; though var. ζ. *nardifolia*, Ledeb., is occasionally met with. The original specimens described by Poiret in Jussieu's herbarium were gathered by Patrin in Siberia. Poiret, after comparing the leaves with those of *Festuca ovina*, says of the flowers: "les fleurs forment presqu'une ombelle à l'extrémité des tiges, au nombre de deux, plus souvent trois, supportées par de longs pédoncules simples, presqu' égaux, uniflores, quelquefois dichotomes." Trautvetter describes a form with "foliis obtusis, apice subtruncatis" (*Pl. Sibir. bor.* p. 34 [1877]), which I scarcely know how to place among the others. It is, however, based on one small specimen, with leaves similar to those of *Alsine arctica*, found in August 1875 between the rivers Olenek and Lena in Siberia. Provisionally it is placed in *grex a*.

Geogr. range. From the Ural Mountains eastward to British

Columbia and the Western United States, and reaching as far north as the Arctic Circle.

Iconogr.—*Regel, Pl. Raddeanæ, in Bull. Soc. Nat. Mosc.* 1862, pt. i. t. 8; (var. ζ) *Ledeb. Ic. Pl. Fl. Ross.* 6; *Hook. Fl. Bor.-Amer.* t. 32; *Reichb. Ic. Pl. Crit.* iv. t. 377; (var. η) *Ledeb. Ic. Pl. Fl. Ross.* 400.

SYN. (forma typica) *A. Laxmanni*, Fisch. *ex* DC. Prodr. i. p. 404.
A. sibirica, Pers. Syn. Plant. i. p. 504.
Eremogone capillaris, Fenzl, Verbreit. Alsin. p. 37.
E. subulata, Fenzl, Verbreit. Alsin. p. 37.

Subsectio 2.—Folia imprimis caulina, lineari-setacea. Semina granulato-tuberculata.

140. A. MACRADENIA, *S. Wats. in Proc. Amer. Acad.* xvii. p. 367 (1881–82); *Robinson, in Proc. Amer. Acad.* xxix. p. 296 (1894).

Glabrescens, glaucescens. Caudex plus minus lignosus irregulariter tortuoso-multiceps. Caules 15–40 centim., valde nodosi. Folia rigida pungentia. Flores in cymam apertam dispositi. Sepala indurata late ovata subcarinata marginato-membranacea nec acuta. Petala obovato-oblonga, calyce multum longiora, basi subauriculata. Semina compressa oblongo-pyriformia.

So named from the well-developed staminal glands. In Gray and Robinson's 'Synopt. Fl. N. Amer.' reduced to a var. of *A. congesta*, but distinct in the large glands.

Geogr. range. W. United States: Utah, Arizona, California.

141. A. FENDLERI, *A. Gray, Pl. Fendl.* p. 13 (1849); *B. L. Robinson, in Proc. Amer. Acad.* xxix. p. 296 (1894).

Glauca, superne glanduloso-puberula. Caules multi erecti, 10–40 centim. Folia basilaria setacea graminea, margine ciliolata vel glabra plus minus pungentia, 50–95 mm.; caulina connata subvaginantia. Inflorescentia dichotoma; cymæ pauci-multifloræ. Sepala lanceolata vel lineari-lanceolata acuminata glandulosa late scariosa, petala æquantia 5-nervia, apice recurva. Petala obovata. Capsula inclusa. Semina pyriforma.

β. diffusa, *Port. & Coult. Fl. Color.* p. 13 (1873).

Viridescens. Inflorescentia magis diffusa; floribus sæpius majoribus.

Hab. Rocky Mountains of Colorado and Wyoming.

Geogr. range —*N. & W.* British Columbia: Fraser River.
E. United States: Nebraska.
S. Los Angelos in California.

Mr. J. Macoun's specimens, gathered in 1879, mark the N. & W. limit.

Iconogr.—*Britton, Ill. Fl. Un. St. Can.* ii. p. 32, t. 1502 (1897).

Subsectio 3.—Folia ovata vel subrotunda. Semina scabra.
a. Petala sepalis longiora.

142. A. SAXIFRAGA, *Fenzl, in Gren. et Godr. Fl. de France*, i. p. 257 (1848); *Tanf. in Parl. Fl. Italiana*, ix. p. 538 (1892).

Nana, subpuberula, cæspitoso-diffusa, 4–8 interdum ad 11 centim. alta. Caudex prælongus polycephalus. Caules ramosi, ramis erectis vel procumbentibus teretibus, pilis transversis vestiti. Folia late ovata vel elliptico-lanceolata acuta uninervia, inferiora petiolata, media et superiora sessilia, patentia, nervo basin versus ciliatulo-puberulo. Flores solitarii, interdum in dichasium triflorum dispositi; bracteæ lanceolatæ patentes. Sepala ovali-lanceolata acuta enervia, margine vix hyalino-membranacea. Petala alba lineato-venosa oblongo-obovata denticulata, sepalis duplo longiora. Ovarium globosum; styli superne a medio intus papillosi. Capsula oblongo-conica obtusa, calyce vix longior.

A. saxifraga, *Friw.*=Alsine saxifraga, *Boiss.* (sp. Rumelica).

Geogr. area.—The Italian peninsula, Sicily, Sardinia, and Corsica.
N. & W. The Alps of Piedmont (*Bertoloni*).
S. & E. Sicily (according to *Gussone*, who cites *Cupani*, 'Panphyton Siculum,' t. 129. fig. *a* [1713]).

Iconogr.—*Guss. Plant. Rar.* t. 37. fig. 1; *Reichb. Ic. Fl. Germ. Helv.* 4913.

SYN. *Stellaria saxifraga*, Bertol. Pl. Ital. rar. iii. p. 55.
Cerastium latifolium (*non* Linn.), Vitm. Ist. Erb. p. 50.

143. A. CILIATA, *Linn. Sp. Plant.* p. 425 (1753); *Willk. & Lange, Prodr. Fl. Hisp.* iii. p. 623.

α. typica, *mihi.*

Folia ovalia subsessilia. Flores 3–7 cymose dispositi apice ramorum; pedicelli 1–3-plo calyce longiores.

β. longipes, *Fouc. & Rouy, Fl. de France*, iii. p. 247 (1896).

Folia majora, late ovalia, in petiolum attenuata. Flores plerumque 1–4, apice ramorum; pedicelli 3–6-plo calyce longiores.

γ. frigida, *Koch, Deutschl. Fl.* iii. p. 267.

Folia ovali-lanceolata vel lanceolata. Flores sæpius tantum 1-2 apice ramorum; pedicelli 1–3-plo calyce longiores. Caules semper permulti.

SYN. *A. gothica* (*non* Fries), Gren. in Bull. Soc. Bot. France, 1869, p. 61.

δ. norvegica, *Gunn.* (sp.) Fl. Norveg. ii. p. 145, t. 9. ff. 7–9 (1772).

Fere glabra. Folia ovata haud ciliata. Pedicelli quam in typo breviores. Sepala subenervia glaberrima.

SYN. *A. humifusa,* Wahlenb. Fl. Lapp. p. 129 (1812).

Extends further north than any other species of *Arenaria*: found in Goose Land, in the island of Novaya Zemlya, during the 'Nordenskiöld' Expedition at lat. 72° N., also in Greenland, lat. 73–74° N. Found throughout the Arctic regions north of Europe and Siberia,—Iceland, N. Norway, Lapland, the island of Vaigatch, Arctic Russia, the territory of the Samoyedes, even to the rugged west coast of Spitzbergen. Authentic specimens of *A. ciliata* had not been examined from Spitzbergen, the present most northerly limit of any species of the genus, at the time of writing my former paper on *Arenaria* *, where the northern limit is given as that of the island of Novaya Zemlya. Sir J. D. Hooker † says that the range of the species extends as far south as the island of Crete. This is due probably to the error in Sibthorp's 'Fl. Græca,' t. 438, where the plant figured as *Arenaria ciliata* is *A. gracilis* var. *cretica.* It extends no further south than Spain. In the mountains of Sligo, in the west of Ireland, the plant ascends to 500 metres; and there is a specimen from here preserved in Buddle's Herbarium under the name of "Lychnis alsinoides parva, flore albo minimo." On the Stelvio Pass, in the Rhætian Alps, where the three frontiers of Switzerland, Austria, and Italy meet, specimens have been found, according to Parlatore, at 2800 metres. Near the bridle-path on the Col de Fenêtre of the Great St. Bernard, in the Swiss canton of Valais, specimens were found by M. Gaston Tissandier at 2750 metres. These are the highest altitudes in the Alps recorded for the species. It was from specimens gathered in the Stelvio Pass that Parlatore drew up his description of the species

* Bull. Herb. Boiss. iii. p. 597 (Nov. 1895).

† Stud. Fl. British Islands, ed. 3, p. 65.

in the 'Fl. Italiana.' In the Spanish Pyrenees, at Puerto de Canfranc, the plant ascends to 1350 metres.

The synonym of *A. multicaulis*, Linn. Sp. Plant. ed. II. p. 605, is included under *A. ciliata* in Sp. Plant. ed. I. p. 425. In the appendix to the former work, Linnæus says,—"Affinis *A. ciliatæ*. Folia non nervosa observavit Jacquinius." Again, in 'Mant. Plant.' p. 386, he says,—"Foliis nervosis videtur *Arenaria ciliata* differre."

Geogr. limits.—*N.* Advent Bay on west coast of Spitzbergen, lat. 78° N., var. δ (*A. F. Battye*, in Mr. Conway's Expedition, 1896—in flower 13 July).

S. Spain: the Escorial, in the prov. of New Castile (*Quer*, Fl. Española [1762–84]).

E. European Russia: island of Vaigatch in the Kara Sea (*Schrenck*).

W. Canada: Kicking Horse Pass, in the Rocky Mountains of the prov. of Alberta (*J. Macoun*), var. δ.

Iconogr.—(Var. α) *Fl. Danica*, t. 346, t. 1269; *Sow. Engl. Bot.* ed. 1, t. 1745; ed. 2, t. 646; ed. 3, t. 238 (very indifferent); *Reichb. Ic. Fl. Germ. Helv.* 4942; *Ic. Taurin.* xxiii. t. 31; *Séguier, Pl. Veron.* i. p. 421, t. 5. f. 2 (1745); *Haller, Hist. Stirp. Helv.* i. t. 17 (1768); *Lodd. Bot. Cab.* t. 659.—(Var. γ) *Wulf.* ap. *Jacq. Collect. Bot. Chem. Nat. Hist.* i. t. 17 (1786); *Reichb. Ic. Fl. Germ. Helv.* 4950.—(Var. δ) *Gunn. l. c.*; *Sow. Engl. Bot. Suppl.* t. 2852; ed. 3, t. 237.

The above include as many figures known to me as are worth citing. Those of 'English Botany,' ed. 3, are far inferior to any of the others, as might be expected from the general crudeness of the plates in this work, which compare very unfavourably with those of Continental illustrated floras. Those of *var.* γ are cited under *A. multicaulis*. The plant figured in 'Fl. Danica,' t. 346, was an Icelandic specimen.

Syn. *Alsine trifolia*, Gould, *ex* Journ. Linn. Soc. xi. p. 298 (1871).
Alsinella ciliata, S. F. Gray, Nat. Arrang. Br. Pl. ii. p. 655.
Arenaria multicaulis, Linn. Amœn. Acad. i. p. 162 (var. γ).

144. A. gothica, *Fries, Novit. Fl. Suec.* ii. p. 33 (1839); *Hartm. Skand. Flora*, ed. 11 (1879), p. 243.

α. typica, *Fouc. & Rouy, Fl. de France*, iii. p. 248 (1896). Planta gracilis, 4–8 centim.

β. fugax, *Fouc. & Rouy, l. c.*

SYN. *A. fugax*, J. Gay herb.
A. ciliata var. *fugax*, Gren. et Godr. Fl. de France, i. p. 359.
A. ciliata var. *laxior*, Gremli.

Planta robustior, 8–12 centim., caulibus numerosioribus.

Fries says, "radix omnino annua," but there is no doubt, so far as the English specimens are concerned, that the plant is either annual or biennial, according to the locality. Dr. Nordstedt, in a letter to Mr. Arthur Bennett, says:—"I think this species varies much in habit; when seeds grow early in spring it is annual; when late in summer, biennial; and in favourable localities perennial, by means of winter-shoots." Mr. W. Whitwell says (in Journ. Bot. 1889, p. 357):—"With *A. serpyllifolia* it could scarcely be confounded. From *A. ciliata* it may be separated by the leaves being sparser, and not appressed to the stem in the lower part (as they usually are in *A. ciliata*); the veins are not nearly so prominent; the armature of the stem is much more like that of *A. serpyllifolia* than of *A. ciliata*; the capsules are larger and longer, and the seeds are larger. From *A. norvegica* it may be known by the whole surface of the plant being more hairy, with transparent gland-like hairs, the margins of the leaves more ciliated, with curved hairs; the seeds more compressed, smaller, and not so dark (or perhaps the present specimens have not fully ripened?)."

Hab. S. Sweden; England, West Yorkshire; Switzerland, lake of Joux.

Iconogr.—*Fl. Danica, Suppl.* t. 15 (1853).

145. A. BALEARICA, *Linn. Syst. Nat.* ed. XII. iii. app. p. 230 (1768); *Tanf. in Parl. Fl. Italiana*, ix. p. 541.

Hab. Sardinia, Corsica (up to 1250 metres), and Mallorca (from 400 to 1400 metres) in the Balearic Islands.

Iconogr.—*L' Hérit. Stirp. Nov.* i. t. 15; *The Garden*, Jan. 1885.

SYN. *A. cæspitosa* (*non* Ehrh.), Salisb. Prodr. p. 299.
A. Corsica, Steud. Nomencl. ed. 2, i. p. 124.

146. A. GLANDULIGERA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 240 (1874); *Jacks. Ind. Kew.* i. p. 179.

Dense glanduloso-pubescens. Caules 2–5 centim., inferne glabri nitidi, numerosi suberecti. Folia pallide viridia utrinque glandulosa mollia plana, acuminata vel acuta, ovata vel elliptico-oblonga, nervis obscuris. Pedicelli tenues, erecti vel cernui. Calyx campanulatus, sepala linearia late membranaceo-marginata,

apice recurva. Petala obovata acuta, alba basi lilacina. Capsula inclusa.

Mr. Duthie's Garhwal specimens show the five glands most distinctly. None of the undamaged petals in the Kashmir specimens examined seemed to be rounded at the apex as stated in Edgeworth's description.

Hab. Alpine Himalaya, from Kashmir to Sikkim, up to 5450 metres.

β. Petala sepalis breviora, vel ea subæquantia.

147. A. BIFLORA, *Linn. Mant. Plant.* p. 71 (1767); *Tanf. in Parl. Fl. Italiana,* ix. p. 543.

Forma elongata, *Heer, in Herb. Polyt. Helvet.* (1867).

Laxior, caulibus magis elongatis.

β. apetala, *Vill.* (sp.) *Prosp. Fl. Dauph.* p. 48 (1779); *Hist. Pl. Dauph.* iii. p. 622, t. 48.

Corolla evanescens.

Linnæus's short description is :—" Caules procumbentes. Folia subrotunda seu obovata, lævia, obtusa. Pedunculi laterales, foliis duplo longiores, bifidi et biflori: bracteis 2, linearibus ad divisionem, ut et in altero pedicello. Calyces ovati. Petala alba. Capsulæ subglobosæ."

Geogr. limits.—N. Austrian Poland. *S.* Albania.
E. Transylvania. *W.* Dauphiny (var. β).

Iconogr.—*Jacq. Ic. Rar. Plant.* 83; *Ic. Taurin.* xv. t. 91. f. 4; *All. Fl. Pedem.* no. 1699, t. 44. f. 4, et t. 64. f. 4; *Reichb. Ic. Fl. Germ. Helv.* 4949.—(Var. β) *Vill. Hist. Pl. Dauph.* iii. p. 622, t. 48.

SYN. *Alsinanthus biflorus,* Desv. Journ. Bot. 1814.
Arenaria multicaulis, (*non* Linn.) Schur *ex* Simonk.

148. A. GAYANA, *Williams.*

Inferne subpubescens, superne glabra. Caules repentes graciles ramosissimi paullum angulati. Folia suborbicularia apice rotundata mucronulato-apiculata, enervia petiolata plana, basin versus parce ciliata. Flores pauci solitarii longe pedicellati. Calyx late campanulatus; sepala ovata obtusa obscure 3-nervia erecto-patentia, margine anguste hyalina. Petala obovata, calyce triente breviora. Antheræ albidæ. Capsula valvis 3 bidentatis dehiscens. Semina reniformi-globosa.—(A. balearica *var.* brachypetala, *J. Gay herb.* in Herb. Kew.)

Hab. Pastriciale in Corsica (*Serafino,* 1828).

Subgenus IV. DICRANILLA.

Sectio i. RADIANTES.

Petala calyce longiora. Stamina 10.

149. A. RADIANS, *Benth. Pl. Hartweg. Mexic.* p. 163 (1839–48); *Jameson, Syn. Plant. Æquat.* i. p. 45 (1865).

Viscidula. Radix prælonga. Folia lanceolata canaliculato-concava subcartilaginea glabra. Sepala lanceolata. Petala oblonga unguiculata radiato-patentia. Antheræ violaceæ. Styli 3; ovula circiter 10. Semina orbiculata.

From the available specimens, which are damaged, no further characters are to be made out. Jameson by a slip of the pen says that the sepals (petals ?) are unguiculate.

Geogr. area. The Andes of Ecuador: Mt. Ilinissa and Mt. Chimborazo, near the line of perpetual snow, and at 1500 metres.

150. A. DICRANOIDES, *H. B. & K. Nov. Gen. et Spec.* vi. p. 34 (1823); *Jameson, Syn. Plant. Æquat.* i. p. 45 (1865).

Habit of *Dicranum glaucum*, Hedw., a moss. The type of this species is *Lobelia bryoides*, Willd. herb. no. 4011.

Hab. The Andes of Ecuador, Peru, and Bolivia.

SYN. *Lobelia bryoides*, Willd. herb. *ex* Roem. & Schult. Syst. Veg. v. p. 41 (1819).

Sectio ii. PYCNOPHYLLÆ.

Petala calyce multum breviora, vel nulla. Stamina 10.

151. A. BISULCA, *Rohrb. in Linnæa*, xxxvii. p. 248 (1871–72) (nomen); *Bartl. in Reliq. Haenk.* ii. p. 12 (1830), *sub* Cherleria bisulca.

Glabra vel tenuissime pubescens. Radix parce fibrosa. Caules valde ramosi, diffuso-cæspitosi, undique procumbentes, tenuissime puberuli, inæquales, 10 centim. Rami ramulique partim æque procumbentes, partim (præsertim floriferi) erecti, approximati tetragoni parce pubescentes. Folia lanceolata acutato-mucronata nitida enervia, dorso convexo sulcis duobus angustis profundis notata, margine incrassata setulis brevibus ciliata, basi non attenuata, fere amplexicaulia necnon connata. Calyx coriaceus nitidus, basi subturbinatus; sepala ovato-lanceolata acuminata omnino glaberrima, extus sicut in foliis caulinis bisulcata. Petala lineari-oblonga, apice emarginata,

calyce duplo breviora. Antheræ subrotundæ. Styli 3 (interdum tantùm 2). Capsula calyce inclusa. Semina 6–10.

So called from the two furrows on the dorsal surface of the leaves and sepals.

Hab. The Peruvian Andes; and Cerro del Campo-Grande in Argentina (*Grisebach* in Götting. Abhandl. 1879, p. 26).

152. A. BRYOIDES, *Willd. herb.* no. 8479, ex *Schlecht. in Gesellsch. naturf. Fr. Berlin. Mag.* vii. p. 201 (1813); *H. B. & K. Nov. Gen. et Spec.* vi. p. 33 (1823).

Habit of *Cherleria sedoides.* The specimens from Guatemala described by Mr. W. B. Hemsley do not seem to differ materially from the type, except in the somewhat tougher sepals.

β. macrophylla, *Fenzl, in herb. Haenke*; ap. *Rohrb. in Linnæa,* xxxvii. p. 250 (1871–72).

SYN. *A. serpens* var. *Orizabæ*, Rohrb. in Linnæa, xxxvii. p. 271.

The specimens of this variety are labelled *Cherleria serpyllacea* Presl, in Haenke's herbarium. There is also an additional note that they were from the Peruvian Andes. Rohrbach is disposed to doubt that Haenke procured these specimens from Peru, and *a posteriori* does not admit the extension of the range of the species to South America. The leaves are larger than those of the type, but not so smoothly shining.

Hab. Mexico: no locality (*Uhde* no. 1104, *Schaffner* no. 489, *H. Christie*, 1871), prov. of Cuernavaca, in the crater of Mt. Popocatepetl (*Aschenborn* no. 730), Mt. Toluca in the prov. of that name at 3600–4700 metres (*Heller* no. 329), prov. of Vera Cruz (*Linden* [1838], no. 938); Guatemala, Volcan de Fuego at 3900 metres and at the summit (*Salvin*).

Iconogr.—*Hemsl. Biol. Centr.-Amer., Bot.* v. t. 4. ff. 14–18.

153. A. PYCNOPHYLLA, *Rohrb. in Linnæa,* xxxvii. p. 250 (1871–72).

Caules multum ramosi; ramuli breves glabri. Folia coriacea late ovata fere obtusa, margine ciliata, ad basin versus membranacea, tantum 2 mm. longa. Sepala ovata obtusa late membranaceo-marginata, duo præfloratione exteriora margine ciliata, cetera glabra, tantum 2 mm. longa. Petala nulla. Capsula oblonga.

Species habitu valde insignis, fere *Pycnophyllum* in memoriam

revocans. Differt a priori habitu, foliorum et sepalorum formâ ac magnitudine, et corollæ defectu. E descriptione huic speciei affinis esse videtur etiam *A. Alpamarcæ*, quæ tamen differt foliis interdum non imbricatis, ovato-lanceolatis mucronatis, 4–6 mm. longis, floribus longe pedunculatis, staminibus 5 nec 10, quæque incertum est an ab *A. nitida* sat differat.

Hab. Bolivia, near Potosi.

154. A. PYCNOPHYLLOIDES, *Pax, in Engl. Jahrb.* xviii. p. 29 (1893).

Glabra. Folia lanceolata acuminata nitescentia subcoriacea, usque ad apicem dense ciliata, nervo mediano subtus valde prominente ciliato, supra plus minus concava. Sepala oblonga acuminata ciliata, late membranacea. Petala apice obtusa, minuta vel nulla. Ovarium depresso-globosum; styli 3.

β. compacta, *Pax, l. c.* p. 29.

A typo recedit ramis valde abbreviatis, dense imbricato-foliatis, cæspites humiles densas formans.

γ. Moritziana, *Pax* (sp.), *l. c.* p. 30.

A typo recedit ramulis inferne foliis delapsis nudis; foliis et sepalis perglabris.

The specimens on which this species is founded were identified with *A. bisulca* by Grisebach (Symbol. p. 26); but this plant has not the characteristic furrows in the leaves which distinguish *A. bisulca*, and the ovary is much broader.

Geogr. range.—Argentina, provs. of Rioja and Salta; Colombia, Mt. Paramo de Muchuchias.

SYN. *A. bisulca* (*non* Rohrb.), Griseb. Symbol. p. 26.

155. A. BOLIVIANA, *Williams.*

SYN. *A. conferta*, Wedd. in Ann. Sc. Nat. sér. V. i. 1864, p. 293 (*non* Boiss. 1842).

Caules multum ramosi, ramulis brevibus glabris. Folia oblongo-lanceolata, margine anguste membranaceo ciliata, ceterum glabra aut nervo mediano prominente vel interdum toto dorso hispida. Sepala ovato-oblonga, margine anguste scariosa, aut duo præfloratione exteriora margine ciliata aut rarius omnia dense villosa. Petala nulla. Capsula ovata, paullum infra medium in 3 valvas bifidas dehiscens. Semina minima lenticularia.

β. villosa (=A. conferta, *var.* villosa, *Wedd. l. c.*).

Hab. Bolivia, prov. Larecaja at 4500 metres; Peru, Mt. Cerro de Pasco, at 4400 metres.

Sectio iii. PEDUNCULOSÆ.

Petala calyce multum breviora, vel nulla. Stamina 5.

156. A. PEDUNCULOSA, *Wedd. in Ann. Sc. Nat.* 1864, p. 294; *Rohrb. in Linnæa*, xxxvii. p. 249 (1871–72).

Pusilla, glaberrima, 1–1½ centim. Folia subcoriacea ovato-oblonga acuta plana, basi connata ciliata. Sepala ovata, dorso parce puberula, margine anguste scariosa. Petala nulla. Capsula ovata exserta. Semina compressa.

Species *A. nitidæ* Peruvianæ affinis, sed diversa foliis dense imbricatis confertis minutis, sepalis ovatis neque lanceolatis apice conniventibus neque plane rectis, etiam floribus apetalis. In utrâque folia plana, tametsi Rohrbach aliter dicit.

Hab. Bolivia: Raico de Chuquiagillo in prov. of La Paz.

157. A. ALPAMARCÆ, *A. Gray, Bot. Un. St. Explor. Exped.* i. p. 116 (1857); *Walp. Ann. Bot.* vii. p. 297 (1868).

Pusilla, glaberrima, 2–5 centim. Folia subcoriacea ovato-lanceolata cuspidata, basi connata ciliata. Sepala coriacea ovato-lanceolata acuta. Petala nulla. Capsula inclusa. Semina 5 vel 6, globulosa.

A larger plant than the preceding, distinguished from it by the included capsule and spherical seeds.

Hab. The Peruvian Andes.

Subgenus V. ARENARIASTRUM.

Sectio i. GOUFFEIA.

Flores minuti, cymoso-paniculati. Stamina 10. Capsula oblonga vel subglobosa, calyce inclusa.—Herba Europæa biennis tenuis diffusa, foliis linearibus vel setaceis.

158. A. MASSILIENSIS, *Fenzl, ex Gren. & Godr. Fl. de France*, i. p. 262 (1848); *DC. Fl. Franç., Suppl.* (1815) p. 609 (Gouffeia arenarioides).

Hab. Siliceous soil in hilly localities of Provence: dept. of

Bouches-du-Rhône, Montredon, Saint-Loup, Carpiagne, near Toulouse; dept. of Var, environs of Toulon, Baon-de-quatre-heures, Montrieux, la Sainte-Baume.

Iconogr.—*Reichb. Ic. Plant. Crit.* iv. 399; *Willk. Ic. descr. Pl. Rar. Hisp.* i. t. 66; *Bory & Chaub. Fl. Peloponn.* n. 701, t. 24. f. 2 (A. Gouffeia, *Chaub.*)—"immerito et ex confusione schedularum herb. Fauché in Græcia indicatur."

Sectio ii. LEPYRODICLIS.

Flores parvi, cymoso-paniculati. Stamina 10. Capsula inflato-globosa, calyce inclusa.—Herbæ Asiaticæ proceræ flaccidæ annuæ, foliis lanceolatis vel oblongo-lanceolatis.

159. A. HOLOSTEOIDES, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 241 (1874); *Boiss. Fl. Orient.* i. p. 668 (1867) (Lepyrodiclis holosteoides).

60–65 centim. Glabra vel glanduloso-puberula. Caulis elongatus, interdum pilis brevibus inspersus, sicco nitidus striatus, usque ad flores dichotome cymoso-paniculatus. Folia deflexa linearia vel lineari-oblonga vel etiam lanceolata, acuta scabrida tenuiter ciliata. Pedicelli cernui, (in typo) calyce longiores. Sepala lanceolata obtusa puberula membranaceo-marginata. Petala alba, obovata vel lineari-spathulata, basi angustata, calycem æquantia vel excedentia, apice retusa, faucem versus venis 3 longitudinaliter notata. Ovula 4. Semina scabra, pallide brunnea.

β. stellarioides, *Williams.*

SYN. *Lepyrodiclis stellarioides,* Fisch. & Mey. in Schrenck, Enum. Pl. nov. (in notâ) p. 93 (1841).

Sepala sub anthesi subpatentia. Petala dilute carnea, anguste lineari-spathulata, emarginata. Capsula minor, magis inclusa. Pedicelli florum calyce breviores.

γ. cerastioides, *Williams.*

SYN. *Lepyrodiclis cerastioides,* Kar. & Kir. Enum. Pl. Soongar. no. 167, in Bull. Soc. Nat. Mosc. xv. 1842, p. 170.

Pedicelli in planta juniore calyce breviores, in planta adulta plerumque illo longiores. Petala alba oblonga emarginata. Capsula minor, magis inclusa.

The variation in the length of the pedicels in these forms shows that the character is not to be relied on elsewhere in the genus as of any specific value.

δ. paniculata, *Williams.*

SYN. *Lepyrodiclis paniculata,* Stapf, in Denkschr. Akad. Wien, li. p. 287 (1896).

Glaberrima, glaucescens, ample et plus minus irregulariter paniculata. Folia lanceolata. Sepala late membranaceo-marginata. Petala alba lineari-oblonga emarginato-biloba.

Geogr. area.—Temperate Asia.

N. Chinese Turkestan: Soungaria.
S. Beluchistan.
W. Turkey in Asia: prov. of Siwas. } *ex Boiss.* Fl. Orient. p. 668.
E. China: prov. of Kansu, north of the river Hoang-ho (*Piasezki, ex* Journ. Linn. Soc. xxiii. p. 70 [1886]).

This is a species of wide distribution, and is found through Russian and Chinese Turkestan, Afghanistan, Beluchistan, and Persia to the eastern part of Asia Minor, on the west coast of the Caspian Sea and in Russian Armenia, in the Western Himalayas, Tibet, Central Mongolia, in the desert of Soungaria and across to the prov. of Kansu in China. At Hopar in Dardistan specimens were collected at 2800 metres (*W. M. Conway,* Exped. to Karakoram Glaciers, 1892), and in the neighbourhood of Gilgit south of the Hindu Kush at 2920 metres (*Dr. Giles,* no. 301, 1887), also in Baltistan in wheat-fields (*Duthie,* 1894.)

Iconogr.—*Cambess.* in *Jacquem. Plant. Rar. Ind. Or.* t. 30 (1842–44), *sub* Gouffeia crassiuscula.

160. A. TENERA, *Edgew. in Hook. f. Fl. Brit. Ind.* i. p. 242 (1874); *Boiss. Diagn. Pl. Or. nov.* ser. II. i. p. 84 (1853) (Lepyrodiclis tenera).

Glabra vel pubescens, intricatim cæspitosa, 5–7 centim. Caules filiformes. Folia longe petiolata. Flores plerumque axillares, pedicellis divaricatis capillaribus suffulti. Sepala lanceolata vel ovato-oblonga acuta puberula membranaceo-marginata. Petala oblongo-linearia, apice integra, calycem excedentia. Styli (pro genere) prælongi. Ovula 4. Semina scabra acute tuberculata.

Facies *A. graveolentis,* sed longe distat; evidentius affinis est *A. longistylæ,* sed herba annua, toro vix concavo.

Hab. N.W. India, Kishtwar and Bemahal in Kashmir; E. Afghanistan, Pashat on the river Kunar (Kafiristan).

Sectio iii. Brachystemma.

Flores numerosi, in paniculis axillaribus vel terminalibus. Stamina 10, quorum 5 ananthera. Capsula depresso-globosa, calycem non superans.—Herba Himalaïca annua subscandens diffusa, foliis lanceolatis vel ovato-lanceolatis.

161. A. nepalensis, *Spreng. Syst. Veg. Cur. Post.* p. 181 (1828); *D. Don, Prodr. Fl. Nepal.* p. 216 (1828) (Brachystemma calycinum).

α. himalaïca, *Williams.*

Panicula glabra vel parce puberula. Folia ovato-lanceolata.

β. khasiana, *Williams.*

Panicula villosulo-pubescens. Folia lanceolata (*Griffith*, in Herb. Kew.).

A climber, often covering trees to a height of six metres from the ground. It commonly occurs at from 300–450 metres in the Himalayas. The species is overlooked in Mr. W. B. Hemsley's 'Index Floræ Sinensis.'

Geogr. limits.—N. & W. Nepal.

S. Prov. of Assam: Munipur (*G. Watt*, 1882).

E. China: prov. of Yun-nan, var. *β* (*Dr. J. Anderson*, 1868).

Iconogr.—*Fenzl, in Endl. Atakta*, t. 16 (*Brachystemma calycinum*).

Subgenus VI. ODONTOSTEMMA.

Sectio i. Barbatæ.

Flores dichotomo-corymbosi, pedicellis elongatis erectis suffulti; bracteæ foliaceæ.

162. A. barbata, *Franch. in Bull. Soc. Bot. France*, xxxiii. p. 430 (1886); *Pl. Delavay.* p. 93.

Caulis 15–25 centim., sæpius solitarius, e medio divaricato-ramosus, dense glandulosus, viscidus. Folia pallide virentia, subtus glauca, oblonga vel oblongo-obovata obtusa, longe ciliata. Sepala lanceolata glanduloso-pubescentia. Petala rosea laciniata, calyce sæpius subduplo longiora. Ovula plura (6–7).

A species characterized by its leaves fringed with long white cilia.

Hab. China: prov. of Yun-nan, at the foot of Mt. Yang-in-chan, 2500 metres above Lankong (1885).

Sectio ii. YUNNANENSES.

Flores cymosi, pedicellis sub anthesi erectis mox deflexis suffulti bracteæ foliaceæ.

163. A. YUNNANENSIS, *Franch. in Bull. Soc. Bot. France,* xxxiii. p. 431 (1886); *Pl. Delavay.* p. 94.

Ramosa, diffusa, pallide virens. Caules graciles inferne glabrescentes, superne pubescentes et tenuissime glandulosi. Folia glabrescentia vel ad nervum et margine ciliata, utrâque facie punctis elevatis asperulata, inferiora breviter sed distincte petiolata, e basi attenuatâ oblonga vel lanceolata, obtusa cum mucronulo, superiora sessilia magis ovata. Pedicelli graciles glandulosi. Sepala lanceolata acuminata glanduloso-pilosa. Petala alba oblonga vel obovata, tenuiter apice fimbriata, calyce vix duplo longiora. Antheræ violaceæ. Semina 3-4, angulata.

β. trichophora, *Franch.* (sp.) *l. c.* p. 431.

Folia hispidula piloso-glandulosa. Inflorescentia paniculato-pyramidata. Ovula plura.

γ. angustifolia, *Franch. Pl. Delavay.* p. 95.

Folia anguste lanceolata acuta, pilis homomorphis omnibus glandulosis vestita. Inflorescentia ampla.

In habit this variety is different from var. β. The leaves are narrower and are provided with hairs which are uniform in structure; they are very short, pluricellular, ringed with brown, and glandular. In the type, on the leaves and sepals, these hairs are found mingled with others which are whitish, formed of two or three much longer cells, and acute, such as are found in *A. glandulosa*, the next species. Var. β is very similar to this next species, but is more robust, and has larger and more numerous flowers.

Hab. China, prov. of Yun-nan: Mt. Pengay-tze above Houang-kiapin, and Mt. Hee-chan-men above Lankong.

164. A. GLANDULOSA, *Williams.*

SYN. *Odontostemma glandulosum*, Benth. *ex* G. Don, Gen. Syst. Bot. i. p. 449 (1831).

A. Benthami, Edgew. in Hook. f. Fl. Brit. India, i. p. 242 (1874), *non* Fenzl (1840).

Caules graciles ramosissimi glanduloso-pubescentes, pilis patentibus articulatis. Folia inferiora petiolata, superiora sessilia, utrâque facie pubescentia, margine ciliata, vix obtusa. Flores nutantes. Sepala oblongo- vel lineari-lanceolata, apicibus recurva. Petala alba obovato-spathulata lacerata. Antheræ ovales luteæ.

Hab. Temperate Himalaya: Kumaon and Sikkim.

165. A. DEBILIS, *Hook. f. Fl. Brit. Ind.* i. p. 242 (1874); *Franch. in Bull. Soc. Bot. France*, xxxiii. (1886) p. 432.

Caulis sæpius solitarius, simplex vel parce ramosus, glanduloso-pilosus, gracilis debilis. Folia oblonga vel oblongo-ovata, obtusa, utrâque facie pubescentia, margine ciliata. Flores solitarii vel in cymis paucifloris; pedicellis divaricatis debilibus gracilibus. Sepala lineari-lanceolata acuta. Petala rosea obovata denticulata.

Very like a small form of the preceding, but smaller in all its parts; the leaves more obtuse; the flowers not 6 mm. across; petals broader and not lacerate, merely irregularly toothed at the tip; filaments much shorter.

Hab. Sikkim: alpine Himalaya, 4200–4800 metres.

166. A. DELAVAYI, *Franch. in Bull. Soc. Bot. France*, xxxiii. p. 432 (1886).

Caules breves ramosi intricati, pilis brevibus glanduloso-hispidulis inspersi. Folia vix obtusa, oblonga, inferiora petiolata, superiora subsessilia. Pedicelli glandulosi, inferiores axillares solitarii, superiores 3–5 cymosi. Calyx basi rotundatus, leviter glandulosus; sepala lanceolata acuta, apicibus nunc recurva. Petala alba late obovata, nunc fere rotundata, laciniata. Antheræ ovatæ luteæ. Ovarium multiovulatum.

Hab. China: prov. of Yun-nan, summit of Mt. Tsang-chan, above Tali, at 4000 metres (1884).

167. A. QUADRIDENTATA, *Williams.*

SYN. *Lepyrodiclis quadridentata,* Maxim. Fl. Tangutica, p. 84, t. 31 (1889).

4–6 centim., intricata, cæspitem sat densum formans. Caulis tener decumbens a basi divaricato-ramosissimus viscido-pubescens. Folia dense pilosa breviter petiolata, lanceolato-linearia vel lanceolata, acuminata vel acuta. Sepala oblonga obtusa. Petala obovata quadridentata, dentibus ovatis vel lanceolatis, sepalis longiora. Ovula 4–5. Semina obtuse tuberculata.

Hab. China: E. Kansu and N. Szechuen.

Iconogr.—*Maxim. l. c.*

Subgenus VII. MACROGYNE.

168. A. LONGISTYLA, *Franch. in Bull. Soc. Bot. France,* xxxiii. p. 433 (1886); *Pl. Delavay.* p. 96, t. 24 B.

Radix gracilis, multiceps. Caules tenues diffusi bifarie pubescentes. Folia oblongo-linearia, apice mucronulata, basi dilatata laxe connata, parce ciliolata. Pedicelli axillares elongati glanduloso-pubescentes. Calyx basi truncatus; sepala inferne glandulifera, lanceolata, abrupte mucronata, margine late albido-membranacea, post anthesin ad basin leviter gibbosa, mox complicata. Petala alba calycem vix superantia, e basi cuneatâ distincte unguiculata obovato-oblonga. Antheræ luteæ subglobosæ. Styli sub lati, calycem longe superantes. Ovula 4–5.

This species is very near *Thylacospermum,* and is a connecting link between it and *Arenaria.* The subgenus *Macrogyne* differs from *Thylacospermum* only in the calyx, which is not tubular, the receptacle being only slightly concave, and in the length of the styles.

Hab. China: prov. of Yun-nan, on Mt. Li-kiang, at an altitude of 4000 metres (1886).

Iconogr.—*Franch. l. c.*

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The admitted species and the synonyms are arranged in a single alphabetical series, each synonym being in *italics*, and followed by the name in parentheses of the species of *Arenaria* to which it is referred.

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nitida, *Rohrb.*, 375.
norvegica, Gunn. (ciliata *var.* norvegica).
obtusiflora, *Kunze*, 344.
orbicularis, *Vis.*, 370.
orbiculata, *Royle*, 356.
Orbignyana, *Wedd.*, 384.
oreophila, *Hook. f.*, 410.
otitoides, Adams (saxatilis).
ovalifolia, *Somm. & Lev.*, 372.
oxypetala, *Sibth. & Sm.*, 357.
palustris, *Naud.*, 387.
Arenaria pamphylica, *Boiss. & Heldr.*, 357.
papillosa, Steud. (graveolens).
paradoxa, Bartl. (lanuginosa).
parviflora, Jacks. [sphalm.] (parvifolia).
parvifolia, *Benth.*, 382.
patagonica, Phil. (palustris *var.* patagonica).
patula, Martr. (serpyllifolia *var.* patula).
pedunculosa, *Wedd.*, 426.
pentandra, *Maxim.*, 373.
persica, Boiss. (Lessertiana).
peruviana, Poepp. (lanuginosa).
Peyritschii, *Rohrb.*, 389.
pleurantha, *Phil.*, 381.
Poeppigiana, *Rohrb.*, 390.
polycnemifolia, *Boiss.*, 393.
polytrichoides, *Edgew.*, 404.
Pomeli, *Munby*, 343.
procera, Spreng. (saxatilis).
Przewalskii, *Maxim.*, 408.
pseudarmeriastrum, *Rouy*, 365.
pubescens, Urv. (graveolens).
pulvinata, *Edgew.*, 405.
pungens, *Clem.*, 393.
pungens, Steph. (capillaris).
purpurascens, *Ram.*, 390.
pusilla, Stapf (pamphylica).
pycnophylla, *Rohrb.*, 424.
pycnophylloides, *Pax*, 425.
pyrenaica, Steud. (montana).
quadridentata, *Williams*, 432.
querioides, Pourr. (incrassata, capitata ?).
racemosa, *Willk.*, 361.
radians, *Benth.*, 423.
Redowskii, *Cham. & Schlecht.*, 353.
reptans, *Hemsl.*, 383.
retusa, *Boiss.*, 356.
rhodia, Boiss. (graveolens).
rigida, *Bieb.*, 409.
rivularis, Phil. (serpens *var.* andicola).
Roborowskii, *Maxim.*, 413.
Rohrbachiana, *Garcke*, 384.
rosea, Salzm. (emarginata *var.* Salzmanni).
rotundifolia, *Bieb.*, 352.
Roylei, Fenzl (festucoides).
ruscifolia, Req. (cinerea).
sabulinea, *Griseb.*, 358.
Salzmanni, Presl (racemosa).
saponarioides, Boiss. & Bal. (macrosepala *var.* minor).
saxatilis, Bout. herb. *ex* Willd. & Lange (obtusiflora).
saxatilis, Lapeyr. (grandiflora *var.* multiflora).

Arenaria saxatilis, *Linn.*, 397.
Saxifraga, *Fenzl*, 418.
saxosa, *A. Gray*, 388.
scabra, Vahl (lanuginosa).
scariosa, *Boiss.*, 402.
scopulorum, H. B. & K. (serpens).
scopulorum, Schlecht. (lanuginosa).
serpens, *H. B. & K.*, 385.
serpens var. *Orizabæ*, Rohrb. (bryoides).
serpyllifolia, Bourg. (nevadensis).
serpyllifolia, Guss. (leptoclados).
serpyllifolia var. *tenuior*, Koch (leptoclados).
serpillifolia, auct. ital. (serpyllifolia).
serpyllifolia, *Linn.*, 365.
serpylloides, C. Gay. (serpens).
setacea, Fisch. (lychnidea).
setacea, Thuill. (capillaris).
setosa, Willd. (capillaris).
sibirica, Pers. (capillaris).
sipylea, Boiss. (graveolens *var.* glabrescens).
soratensis, *Rohrb.*, 381.
sordida, Chaub. (emarginata).
spathulata, *Desf.*, 389.
sphærocarpa Martr. (*non* Tenore), (serpyllifolia *var.* patula).
sphærocarpa, Tenore (serpyllifolia *var.* scabra).
squalida, Dur. (emarginata *var.* Salzmanni).
stenophylla, Ledeb. (saxatilis).
Steveniana, Boiss. (blepharophylla *var.* breviflora, *Williams*).
stolonifera, Vill. (grandiflora *var.* stolonifera).
Stracheyi, *Edgew.*, 374.
Stuebelii, *Hieron.*, 388.
stygia, Boiss. (gracilis *var.* stygia).
subulata, Ser. (capillaris).
Szowitzii, *Boiss.*, 395.
tenella, *Duthie*, ined., 356.
tenera, *Edgew.*, 428.
tenuis, J. Gay (controversa).
tetragyna, *Willd. herb.* ap. *Schlecht.*, 407.
tetraquetra, All. (capitata).
tetraquetra, *Boiss.*, 361.
tetraquetra var. *aggregata*, Reichb. (capitata).
tetraquetra (excl. var. β.), Linn., *Mant. Plant.* (capitata).
tetrasticha, *Boiss.*, 401.
tmolea, *Boiss.*, 352.
tomentosa, *Willk.*, 354.
transsilvanica, Simk. (rotundifolia).
tremula, *Boiss.*, 367.
trichophora, Franch. (yunnanensis).
Arenaria *trichotoma*, Boiss. (Ledebouriana *var.* parviflora, *Boiss.*).
triflora, Linn. (grandiflora *var.* triflora).
Tschucktschorum, *Regel*, 411.
ucranica, Spreng. (graminifolia).
uralensis, Pall. (serpyllifolia *var.* viscidula).
ursina, *Robinson*, 412.
valentina, *Boiss.*, 350.
varia, Dulac (serpyllifolia).
viscida, Hall. f. (serpyllifolia).
viscosa, Fisch. (capillaris).
Wallichiana, Ser. (serpyllifolia).
yunnanensis, *Franch.*, 430.
Bigelowia elongata, Rafin. (lanuginosa).
montana, Rafin. (montana).
Brachystemma calycinum, D. Don (nepalensis).
Brewerina suffrutescens, A. Gray (congesta *var.* suffrutescens).
Cerastium arenarioides, Crantz (spathulata).
latifolium, Vitm. (Saxifraga).
purpurascens, Fenzl (purpurascens).
Cherleria bisulca, Bartl. (bisulca).
grandiflora, D. Don (globiflora).
juniperina, D. Don (densissima).
nitida, Bartl. (nitida).
Dolophragma globiflorum, Fenzl (globiflora).
juniperinum, Fenzl (densissima).
Dufourea purpurascens, Gren. (purpurascens).
Eremogone airæfolia, Fenzl (capillaris *var.* airæfolia).
capillaris, Fenzl (capillaris).
cephalotes, Fenzl (cephalotes).
cucubaloides, Hohen. (cucubaloides).
davurica, Fenzl (juncea).
formosa, Fenzl (capillaris *var.* formosa).
graminea, C. A. Mey. (graminea).
graminifolia, Fenzl (graminifolia).
gypsophiloides, Fenzl (gypsophiloides).
Holostea, Rupr. (Holostea).
juncea, Fenzl (juncea).
longifolia, Fenzl (saxatilis).
lychnidea, Rupr. (lychnidea).
micrantha, Schur (graminifolia).
nardifolia, Fenzl (capillaris *var.* nardifolia).
otitoides, Fenzl (saxatilis).
procera, Reichb. (saxatilis).
pungens, Fenzl (pungens).
rigida, Fenzl (rigida).
stenophylla, Fisch. & Mey. (saxatilis).

Eremogone subulata, Fenzl (capillaris).
Euthalia rotundifolia, Rupr. (rotundifolia).
serpyllifolia, Rupr. (serpyllifolia).
Gouffeia arenarioides, Rob. & Cast. (massiliensis).
crassiuscula, Cambess. (holosteoides).
holosteoides, C. A. Mey. (holosteoides).
Gypsophila aggregata, Linn. (capitata).
succulina, Calv. et Zohrab, 1867 (blepharophylla), 403.
Lepyrodiclis cerastioides, Kar. & Kir. (holosteoides *var.* cerastioides).
holosteoides, Fenzl (holosteoides).
paniculuta, Stapf (holosteoides *var.* paniculata, *Williams*).
quadridentata, Maxim. (quadridentata, *Williams*).
stellarioides, Fisch. & Mey. (holosteoides *var.* stellarioides, *Williams*).
tenera, Boiss. (tenera).
Lobelia bryoides, Willd. herb. (dicranoides).
Micropetalum lanuginosum, Pers. (lanuginosa).
Mœhringia nemorosa, Fenzl (lanuginosa).
umbrosa, A. Gray (saxosa).
Odontostemma glandulosum, Benth. (glandulosa, *Williams*).
Pettera graminifolia, Reichb. (saxatilis).
Plinthine aggregata, Reichb. (capitata).
tetraquetra, Reichb. (tetraquetra *var.* pyrenaïca).
Spergula ciliaris, Brot. (conimbricensis).
Spergulastrum lanuginosum, Michx. (lanuginosa).
Stellaria aculeata, Scop. (grandiflora).
Arenaria, Linn. herb. (spathulata).
elongata, Nutt. ((lanuginosa).
Kingii, S. Wats. (congesta *var.* Kingii).
lanuginosa, Torr. & Gray (lanuginosa).
longepedunculata, Baldw. (lanuginosa).
muralis, Link (capitata).
pubescens, Willd. herb. (lanuginosa).
saxatilis, Scop. (saxatilis).
Saxifraga, Bertol. (Saxifraga).
serpyllifolia, Scop. (serpyllifolia).

The Comparative Anatomy of certain Genera of the Cycadaceæ *.

By W. C. Worsdell, F.L.S.

(Plate 20.)

[Read 3rd February, 1898.]

Introduction.

Material of various Cycadaceous plants having at different times within the past year or two been placed at my disposal, I made a careful investigation of the anatomical structure of the plants concerned. The greater part of the material afforded little of a novel character, but one or two of the plants examined exhibited interesting and striking structures. It was considered worth while to describe in a single paper each plant in succession which I had investigated, although the structure of some of these differs little from what has already been described in other

* From the Jodrell Laboratory, Royal Gardens, Kew.

plants. As our knowledge of the anatomy of the Cycads is at present somewhat meagre, it seems desirable to record any fresh observations on the internal structure of plants of that order even when that structure is of a comparatively normal type.

Cycas revoluta, *Thunb.*

Young Seedling.*

I examined two young seedlings of this plant. The chief points in their structure, to be described below, are *the vernation of the cotyledons*, *the structure of the vascular bundles of the latter*, *the connexion of these bundles with the stem*, and *the extrafascicular vascular structures of the hypocotyl.* In one of these seedlings the plumule is scarcely as yet visible between the stalks of the cotyledons, and the radicle still quite short (Pl. **20.** figs. 1 & 2). The other seedling is somewhat older, the plumule having grown out, bearing two conspicuous scale-leaves which almost completely enclose it (figs. 3 & 4). The hypogeal cotyledons are united together and embedded in the endosperm of the megasporangium (fig. 3): they are thick and fleshy; the two together, united by their ventral surfaces, are round in contour, as seen in transverse section. They separate at the tips, as they do below in the stalk. Each cotyledon has, morphologically, a conduplicate vernation: this is proved, first, by the arrangement of the bundles in a **Λ**-shape, the open part of which is directed towards the ventral surface; secondly, by an indication, in the free tip of the cotyledon, as seen in transverse section, of the place of union of the two folded portions of the lamina by a line of cells, smaller in size and with more conspicuous nuclei than the rest, extending a short way inwards from the ventral face; one of the two lobes thus formed is considerably larger than the other. Some endosperm extends part way along the ventral surface of the organ.

The **Λ** opens out more or less markedly in the tip of the cotyledon, as also below in the lower part of the stalk, regions where the organ becomes more flattened and less angular in shape. The cotyledons, except at the tip, are completely connate and are not easily separable. In transverse section the place of union of the two is indicated by two rows of cells running across

* *Cf.* Bower: "On the Comparative Morphology of the Leaf in Vascular Cryptogams and Gymnosperms," Phil. Trans. vol. 175. 1884, p. 583.

the broadest part of the circular section, which are smaller, squarer, and more compactly joined together than those of the rest of the tissue. In one of the small seedlings one of the cotyledons is partly aborted; the other is considerably contorted and slightly folded round the smaller one.

In the tip of the cotyledon, as seen in transverse section, are five bundles, one of which lies right on the edge of the endosperm. They are *collateral* in structure. The chief peculiarity is the development of a very conspicuous transfusion-tissue arising from the centripetal xylem, which I have already described in a former paper *. This transfusion-tissue is not seen in such great development in the larger seedling, only the smaller tracheides of this tissue which occur on the sides of the phloem are there seen. It disappears lower down in the cotyledon. The centrifugal xylem gradually predominates as the bundles approach the base of the cotyledon. In each cotyledon the five bundles fuse into three, which pass into the stem to form part of the central cylinder. This course of the cotyledonary bundles into the stem is interesting inasmuch, as is also the case with those of the scale-leaves, it differs from the girdle-leaf-traces of the foliage-leaves in being perfectly *straight*, and radial in direction, whereas the girdles assume a tangential and circular direction through the cortex of the stem. This latter course of the bundles is probably, therefore, a modern acquirement, the leaf-trace bundles originally having a straight course like those of the scale-leaves and cotyledons. As seen from the respective places of insertion of their bundles, the cotyledons are not both placed at the same level on the stem. Eventually, the central group of bundles of the stem, which are entirely collateral in structure, and whose xylem is wholly centrifugal, form a cylinder whose bundles, in one or two places, are united to form an arc.

A transverse section of the young plumular leaf shows a group of eight or nine bundles forming an irregular Ω; they appear under a low power perfectly concentric structures; in reality, the phloem lies on one side only, though very much curved into an arc of tissue around the minute group of scarcely thickened tracheides; the phloem fibres are also already differentiated.

Unfortunately, the exact transition from stem to root was not

* "Transfusion-tissue: its Origin and Function in the Leaves of Gymnospermous Plants": Trans. Linn. Soc. ser. II. Bot. vol. v. 1897, pp. 301–319.

seen; it must take place very high up, immediately below the insertion of the cotyledons.

In the larger seedling, in the region close beneath the insertion of the cotyledons, viz. in the upper hypocotyl, there is an oval cylinder of well-developed secondary xylem and phloem enclosing a parenchymatous tissue in which is the diarch plate of xylem with its protoxylem group at each end, though this latter is becoming broken up and the pith smaller in area in the uppermost part of this region. In the phloem, especially in the well-marked primary phloem, are numerous fibres, somewhat resembling tracheides as seen in transverse section. Outside this is a zone, several layers thick, of pericycle, bordered externally by a well-marked endodermis. In the pericycle of this region of the root *concentric strands* occur which, to the number of three or four, and varying in size and development, occupy isolated positions around the central cylinder. They are conspicuous and well-developed. Their central portion is filled with scattered, isodiametric tracheides with reticulate thickenings, which are formed by a surrounding cambial layer; the latest-formed xylem-elements on the periphery of these are rather more regular in shape and position; phloem surrounds the whole, thus completing the stele (fig. 5). Lower down in the hypocotyl it is seen how these structures originate. A cambium arises in the pericycle, forming phloem *on the inside* towards the central cylinder, and xylem on the outside. In some places, at the end of the central cylinder, the extrafascicular cambium is seen to be continuous with the normal cambium of the central cylinder. Gradually passing into the upper hypocotyledonary region, this anomalous cambium extends round and forms eventually the concentric strands. This is evidently the same phenomenon as that described by Gregg in the root of *Cycas Seemanni*, Al. Braun *, although in my seedling the cambium has the form of a local ring, and never forms a zone round the central cylinder.

In a younger part of the root, where secondary thickening of the central cylinder has, however, begun, there is as yet no trace of the extrafascicular cambium.

The youngest part of the root of the larger seedling is triarch, each group of protoxylem being forked, with diverging arms. An outer periderm of three or four layers is present. The

* 'Annals of Botany,' vol. i. 1887.

youngest part of the root of the young seedling appears to have four protoxylem groups.

We thus see that it is as part of the earliest-formed tissues of the seedling that the anomalous strands arise, for they gradually dwindle and disappear both in passing upward into the plumular stem and downward into the root.

The tracheides in the plumular stem, cotyledons, and scale-leaves have scalariform thickenings on their walls, which, however, merge into slit-like pits and close reticulations.

Older Seedlings.

Two other seedlings of this plant came to my hand, both of which are very much older than the last two described, and have already undergone a considerable amount of secondary thickening; they bear two or three foliage-leaves. The chief features in their structure, to be enlarged upon below, are: ***the extrafascicular collateral zones of secondary thickening outside the central cylinder, the secondary concentric strands and the obliquely outgoing strands in the cortex***, and ***the occurrence of centripetal xylem in some of the leaf-traces in the stem.***

In the hypocotyl and the lowest part of the stem the central cylinder is surrounded by a conspicuous irregular band of vascular tissue, consisting of xylem and phloem in the normal position, which in places is broken up into small semi-concentric strands. In one of the plants, an extra strand, but very weak and inconspicuous, and with *inverted orientation* of parts, occurs between the central cylinder and the first extrafascicular strand (cf. *Macrozamia Fraseri*, Miq.) *. Lower down in the hypocotyl these extrafascicular strands break up into *concentric* structures, several in number and of different sizes, which still lower down die out. Passing in the opposite direction upward through the stem, the outer strands become reduced and isolated and finally fuse with the central cylinder. Some, however, appear to end blindly in the cortex.

These strands are all secondary in origin, and doubtless represent a more advanced stage of the small concentric strands described in the root of the young seedlings.

In the hypocotyl broad strands are seen passing out obliquely from the central cylinder, some of which arise opposite a proto-

* Worsdell: "On the Anatomy of *Macrozamia*, as compared with that of other Genera of the Cycadeæ," Ann. Bot. vol. x. 1896, pp. 610–612.

xylem group, while others apparently arise from the region between two protoxylem groups. Some of these strands remain close outside the central cylinder, with which they once again fuse in another part of their course. Others pass farther out, and become split up into three or four concentric strands or parts of such. In the outer part of the cortex they assume a vertical course; their tracheides are twisted about and run in almost every direction. These strands, after their parts have become fused into a single circular strand, whose centre is occupied by short and angular tracheides, die out completely where that part of the cortex which they traverse abruptly terminates, and the root assumes a much smaller diameter.

In one place a small strand is seen running off straight to the margin of the root.

All these structures, passing obliquely or radially outward from the central cylinder, possibly represent the relics of an effete lateral root-system, but of this I can say nothing certain.

In the other part of the stem occur other *very small*, round, *concentric strands* which are seen to run up to the base of the leaves (fig. 6). They probably die out lower down in the stem, but this was not traced. Along their vertical course they fuse here and there with leaf-traces; they also branch frequently, and are therefore very unequal in size, varying also considerably in shape in different parts of their course; in places they open on one side, forming a small gap. In the upper part, near their termination, the strands become crescent-shaped and collateral in structure, and eventually fuse, just under the base of a leaf, with a leaf-trace bundle.

The small strands just described are purely cauline structures, belonging to a system external to the extrafascicular strands which occur immediately around the central cylinder, and pertaining to the same category as the cortical cauline strands already known to occur in the adult stem of *Cycas*.

Some of the *leaf-trace bundles*, observed *in the cortex of the stem*, have some *centripetal xylem*, which is quite conspicuous; many have already lost it while still in the leaf-base. The occurrence of this tissue in these bundles is interesting, for it is a rarity in the vegetative system, and is here to be considered as constituting an abnormal variation from the usual type of structure in these leaf-trace bundles.

Cycas media, *R. Br.*

Adult Plant.

I investigated a large stem of this species, about 14 inches in diameter, and containing about *a dozen vascular rings*; the structure, therefore, would be in every respect much more advanced than in the previous specimens of *Cycas* which I had studied.

The only *special* points to be noted here are: *the peculiar structure of the girdle-leaf-trace bundles*, and *the large concentric strands in the cortex*, the remaining parts of the structure being sufficiently normal.

In the outer part of the cortex there is a very thick formation of periderm, consisting of but a small quantity of cork, but a very large amount of phelloderm, the latter containing great numbers of stone-cells.

Running obliquely out from the periderm in a tangential direction are the girdle-leaf-trace bundles, with their xylem directed inwards. As seen in transverse section, *i.e.* in a radial section of the cortex, these bundles are elongated radially and are rather narrow tangentially. They present a peculiar feature which has not been noticed in the girdles before either of this or any other genus, inasmuch as they exhibit a distinct tendency to assume a *concentric* structure, a cambium extending round in circular form on either side of the bundle and forming several layers of parenchyma, amongst which occur, either in small groups or singly, isodiametric or slightly elongated, reticulate tracheides, of very irregular, angular shape. In some bundles the concentric disposition of these secondary cells is not so obvious, but in others they form a nearly complete circular strand, of which the bundle is a segment. As seen in longitudinal section of the bundle, the xylem of its main part consists, on the inner side, of a band of reticulate elements, which are succeeded by scalariform tracheides, next to these come tracheides with very thick walls, and, apparently, simple pits, for no border is seen to be developed; the tracheides nearest the phloem have very narrow, elongated, bordered or scalariform pits. These girdles have an irregular course, and there occur, moreover, between them curved radial connexions.

In some parts of the cortex, at its extreme outer edge, and

just to the inside of the periderm, are found the *cauline cortical strands* which run perpendicularly through the stem. At this stage in the development of the stem they are of large size and are greatly extended in the tangential direction, but very narrow radially (Pl. **20**. fig. 7).

They have a distinctly *concentric* structure, though, owing to the compression which they have undergone through the growth of the stem, they appear rather to consist each of two mutually inversely orientated strands, of which fig. 8 represents only a small portion. In the central region of such a strand is a dense mass of tracheides, irregular and angular and mostly isodiametric in shape, and lying in every conceivable direction; many of them have beautiful reticulations on their walls, others bordered pits (fig. 9). Mettenius, in his description of these cauline strands, speaks of these tracheides as pertaining to the pith, which is a very natural inference from their position and very irregular arrangement. They belong, however, to the xylem, and are in reality the elements first formed by the cambium on the inner side of the latter. Subsequently, the cambium forms eight or ten layers of tracheides of the normal kind, which occur, as seen in transverse section, either in single rows or in groups of two or three rows, these strands being separated by wide rays of parenchyma. The phloem is of about the same thickness and contains great numbers of small fibres. As seen in longitudinal section, the tracheides have bordered or scalariform pits. The whole of the tissues composing these cauline strands are secondary; and the strands are situated immediately to the inside of the periderm, if not partially embedded therein, for the large stone-cells characteristic of the periderm occur in abundance in the phloem of these strands, and appear to be in radial rows which are continuous outward with those of the periderm. These strands are not always perfectly vertical, but occasionally assume for a short distance a horizontal course; at intervals the place of juncture with a leaf-trace bundle is observed.

The *vascular zones*, as above stated, are twelve in number. The segments composing them are very irregular in position and the tracheides have the usual curved, bent course, as seen in tangential section. The innermost zone of wood is very much subdivided in places into single rows of tracheides, the parenchymatous tissues being greatly developed. Remnants of the

protoxylem can be detected in the outermost region of the pith. The tracheides of the secondary wood have the usual bordered pits. On the inner side of each zone of wood can usually be seen the short, angular, irregularly-shaped tracheides that were observed in *Macrozamia* * in a similar position; they often occur in vertical rows, at other times are irregularly scattered in the parenchyma. They are the first-formed tracheides of the outer, secondary zones of wood, and are of the same nature as those of the cortical strands above described. They usually have bordered pits on their walls, but often have a kind of reticulation instead, which is probably due to the absence of the borders in closely-set pits. The phloem of the secondary zones has often only half the thickness of the xylem; it contains, as in all Cycads, numerous fibres.

In both transverse and tangential section the course of the leaf-traces through the medullary rays is very well seen. In the latter section, where they are transversely viewed, their orientation is seen to be rather diverse, the xylem being directed either upwards, sideways, or obliquely.

The structure of the stem, as seen in this plant, is therefore an extension, and the ultimate outcome, of the structure observed in the much younger plants of *Cycas revoluta*, Thunb.

Macrozamia spiralis, *Miq.*

Young Seedling.

Two plants, both still attached to the megasporangium, came under my investigation, one of which had developed one or two foliage-leaves, the other, being much younger, had as yet developed none.

The only points of importance in the anatomy are: *the similarity in structure of the cotyledons to what obtains in* Cycas, *the absence of any unusual structure in the pith of the stem,* and *the occurrence of obliquely outgoing strands in the hypocotyl.*

In the *cotyledon* the bundles are arranged as in the case of *Cycas.* They are quite collateral in structure, but some amongst them are more or less curved. A large amount of centripetal xylem is present, some of which extends round to the sides of

* Worsdell, in Ann. Bot. vol. x. pp. 608, 613.

the bundle; the outermost tracheides are larger and have reticulations on their transverse walls, some of the latter being interspersed amongst the ordinary tracheides of the centripetal xylem. Thus the same transition occurs here between the centripetal xylem and the transfusion-tissue as is the case in *Cycas*.

The bundles of the petiole of the young *foliage-leaf* have the normal Cycadean structure, the xylem consisting, in the upper part of the organ, chiefly of centripetal, in the basal part almost entirely of centrifugal xylem. An interesting transition between these two types of xylem-development can be followed where, in proportion as the centripetal xylem decreases, the centrifugal xylem increases in quantity, until the latter completely replaces the former.

A transverse section of a thick scale, situated in the region between the insertion of the cotyledon and that of the foliage-leaves, shows it to possess three bundles with mesarch structure and four or five mucilage-canals; in each of the latter is a fringe of thyloses, these not having extended as far as the centre. On the dorsal side of the scale are two distinct layers of periderm, which become confluent towards the margin.

The *stem* exhibits a single cylinder of vascular tissue. The xylem-strands, as usual in Cycads, have a very irregular, curved course. Reticulate protoxylem-elements occur on the inner side of the wood.

As showing what marked and important variation in structure may occur between two *species* of the same genus in this order, I may recall the structure of the stem of *Macrozamia Fraseri*, Miq., in which, besides the first-formed cylinder, two or three others arise successively on its outer side; while in the pith a well-developed cauline system of bundles is present *. In *M. spiralis*, Miq., neither of these highly interesting characters in the structure obtain. It is true that I am describing very young plants of this species; but I feel sure that they are not so young but that, if these characters were really possessed by the plant, they would already have given some indication of their presence.

In a transverse section of the hypocotyl, where the central cylinder is still of considerable thickness, strands of vascular tissue are seen passing obliquely outward from the

* Worsdell, Ann. Bot. vol. x. 1896.

central cylinder, so that throughout their course they appear in transverse section. They contain isodiametric, reticulate tracheides. In one case such a strand is seen to divide into three distinct parts, apparently possessing root-structure, of which the middle strand passes directly outwards, and one to either side in a tangential direction. It is possible that these strands belong to an effete system of lateral roots; and it is probable that they are of the same nature as the large compound strands described on a previous page as occurring in the cortex of the hypocotyl of *Cycas revoluta*, Thunb., but one cannot speak with any certainty. Two cases of dichotomous branching of a lateral root were observed in a younger seedling, in which the root-stele passes *directly* outward from the diarch stele of the parent root and in the outer part of the cortex dichotomizes so that each branch diverges to one side, passing obliquely away; a knob-like projection on directly opposite sides of the root indicates the position of the young lateral roots, which, however, would probably never become anything more than rudiments.

Lower down the root becomes extremely swollen; owing to the enormous increase of the parenchymatous tissues, the vascular strands composing the central cylinder become widely separated and scattered throughout the ground-tissue, and are relatively but little developed and few in number. Characteristic thin-walled sclerides occur in groups in the pith, cortex, or medullary rays of the xylem.

In the lower portion of the root, where its fleshy consistence has disappeared, the characteristic diarch plate is found. The pericycle consists of from 5–8 layers of cells and is bounded by a conspicuous endodermis. Dark-walled fibres occur scattered in the cortex. Two layers of periderm are to be observed—the one external and hypodermal, the other internal and occurring immediately to the outside of the pericycle.

STANGERIA PARADOXA, *T. Moore.*

Young Seedling.

It was my good fortune to be able to investigate a young seedling of this plant grown in the Royal Gardens.

As the adult plant exhibits, both in its foliage and in the mesarch structure of the vascular bundles of the peduncle, a

striking approach to the more primitive conformation and structure of Ferns, I began my study of the seedling plant with the full expectancy of discovering some primitive character or other which would serve to distinguish it in some way from Cycads generally. And in this I was not disappointed, for the especial point to be insisted upon in the following description is *the presence of concentric bundles in the cotyledon*, which must be regarded as of great importance; beyond this, the only character worth noting is *the presence of obliquely outgoing strands in the hypocotyl*, which supply an endogenously arising lateral appendage.

The young plant was attached to the megasporangium by its cotyledons (Pl. **20**. fig. 10); it bore a small foliage-leaf of four pinnæ and a very short radicle (figs. 11 & 12).

Each cotyledon has, in the upper part, four bundles arranged in a row parallel to the greatest width; each bundle consists of well-developed phloem, a small protoxylem-group, and several centripetal tracheides (fig. 13). In the lower part of the lamina of the cotyledon and in its stalk, besides the row of four or five bundles, there are two or three others towards the ventral side, which may be orientated like those of the normal row or may lie sideways. Ascending towards the upper part of the organ, however, the phloem of these inner bundles tends to disappear, and about halfway up it may be either quite absent or represented by but a few inconspicuous elements. (This may also occur in the basal part.) At length, in the upper region, these bundles entirely lose their phloem and their xylem becomes united each with one of the normal bundles.

Descending towards the basal region, the bundles gradually become more and more *concentric*, until the majority are completely so. Those at the ends of the row remain semi-concentric, being still more or less collateral. The *concentric bundles* are extremely small, offering a striking contrast in this respect to the much larger collateral bundles of the upper laminar region. Their centre is occupied by a small group of primary xylem; no secondary tracheides are present. Primary phloem, at least in some bundles, would appear to occur all round (fig. 15); in other cases the bundle is enclosed on the ventral side by secondary phloem only. It will thus be seen that in the cotyledon of this plant a clear case exists of *primary concentric bundles*. I know, moreover, of no other instance in the vegetative foliar organs of modern Cycads where such structures are met with.

In the *stalk* common to the two united cotyledons there are four small bundles in the normal row of each half, mostly entirely *concentric* (fig. 14), and one much larger bundle, collateral in structure and normally orientated, situated towards the inner side of each half.

This large inner bundle has well-developed xylem and phloem in the normal position. On its inner side there are several irregular divisions in the cells bordering on the xylem. Higher up in the cotyledon, but still in its basal part, the large inner bundle has a little phloem on the ventral side of the xylem, but the phloem here appears to be dying out all round.

In the upper part of the stalk of the cotyledon, where it has become a distinct and separate organ, the tracheides of the inner bundle become large and more or less isodiametric; divisions representing phloem occur on *both sides* or *all round* the xylem, the latter case constituting it a *concentric* structure; the divisions on the ventral side are much more definite and regular. Protoxylem is not here easy to distinguish, though in one case one or two small elements are seen adjoining the most definite divisions. Still lower down in the stalk the tracheides are seen to run out away from the bundle in a tangential direction, and are here large, isodiametric, and angular. They eventually, lower down, as shown by the succeeding sections, entirely vanish. The phloem also disappears. The small normal bundles of the cotyledon, in the lower part of the stalk, lose their complete concentric structure (fig. 16).

Periderm arises all round the stalk of the cotyledon, cutting off the outer few layers of cells.

In the lamina of the cotyledon bordering on the crushed endosperm-layer, is a very conspicuous absorptive layer. Its cells have thick walls, dense protoplasmic contents, and conspicuous nuclei.

I consider it highly probable that the *primary concentric bundles* of the cotyledon of this plant, like the primary concentric strands in the peduncle of the mature plant*, are relics of a structure which was once, probably, a common feature of the ancestors of the Cycadaceæ, the concentric very frequently replacing the collateral arrangement of the vascular strands in those days. As an instance amongst fossil plants which I believe to be nearly

* D. H. Scott: "The Anatomical Characters presented by the Peduncle of Cycadaceæ," Ann. Bot. vol. xi. 1897.

related to Cycads, I may recall the primary concentric bundles in the petiole of *Lyginodendron* *, and in that of *Calamopitys Saturni* of Unger †. In another nearly allied fossil group, however, the *Medulloseæ*, the petioles, generally known under the name of *Myeloxylon*, usually possess collateral bundles; but the small concentric strands occurring in abundance in the cortex of some specimens of stems of *Medullosa* are leaf-traces ‡, although before entering the leaves they split up into collateral bundles. Regarding, then, these concentric bundles in *Stangeria* as primitive structures, it is but natural to find the region where the bundles are most clearly concentric to be the upper part of the cotyledonary stalk, which is, in all probability, the oldest part of the organ, so that the bundles from this point run through tissues which, in the upper part of the organ, have been formed by later apical, in the lower part by later intercalary growth.

The young *foliage-leaf* which the seedling bore possesses a lamina consisting of four leaflets (Pl. **20**. fig. 12). The bundles of the petiole, in its lower part, are three in number, corresponding to the blunt, triangular form of the organ. Each bundle has a few large, centripetal tracheides, and often, but not always, one or two small centrifugal ones.

About two-thirds of the way up the petiole are one or two small sharp projections, like remnants of spines. These show periderm formation on their inner side, offering the appearance in section as if some appendage had been there cut off: they may possibly represent rudiments of pinnæ §. In the uppermost part of the petiole just below the lamina the bundles are four in number, one or two of which, by their double protoxylem, show signs of forking. The petiole has here two lobes on the ventral face.

The midrib of the pinna has two bundles, each with one or two centrifugal tracheides. The bundles in the mesophyll are exceedingly small, often containing only two or three small

* Williamson & Scott: "Further Observations on the Fossil Plants of the Coal Measures," part iii. p. 712, Phil. Trans. Royal Soc. 1896.

† Solms-Laubach: "Pflanzenreste des Unterculm von Saalfeld," Abhandl. d. k. Preuss. Geol. Landesanstalt, neue Folge, Heft 23, p. 65, plate iv. (1896).

‡ Weber & Sterzel: 'Beiträge zur Kenntniss der Medulloseæ,' pp. 17–20, figs. 7 & 8 in text, fig. 2, plate i., figs. 1–4, plate iii. (1896).
Solms-Laubach: "Ueber *Medullosa Leuckharti*," Bot. Zeit. 1897.

§ F. O. Bower, in Phil. Trans. vol. 175. p. 590.

tracheides, none of which are centrifugal; but there is a large amount of phloem.

The young *stem* shows four bundles in transverse section, of ordinary collateral structure and with centrifugal, but no centripetal, xylem. Besides these central bundles there are six others running obliquely inward. These are the *cotyledonary* bundles, three belonging to each cotyledon. Before uniting with the four central bundles they would doubtless fuse into a smaller number, but I did not succeed in obtaining sections at a level low enough to see this. Higher up in the stem the four central buudles are seen to gradually split into a greater number, which respectively and mutually alter their positions. The larger products pass outwards to provide the first one or two *leaves*. The smaller products remain in the central region and form an arc which is the nucleus of the *youngest leaf*; immediately on the side of this is the apex of the *stem*, consisting of meristematic tissue.

The transition from stem- to root-structure was, unfortunately, missed.

The uppermost part of the *primary root* shows a *triarch* stele. Between the three protoxylem groups are equally far-protruding xylem-masses, each with well-developed phloem on its outer side. These are partly the result of the secondary thickening which is present. Lower down, at two or three different levels, a lateral strand is given off, which, in one or two cases, appears to arise opposite one of the groups of xylem and phloem with secondary thickening situated between the protoxylem groups, as the conspicuous phloem-mass seems to be carried onward. The xylem becomes entirely surrounded by phloem as the strand passes outwards and downwards in an oblique direction, appearing all the time in transverse section. Its tracheides are angular and isodiametric. Lower down it is seen to pass outwards into an endogenously-arising organ. It may be that the first-formed lateral roots in the upper part of the primary root arise endogenously from the outermost part of the cortex, and that all the later-formed roots arise in the normal way from the pericycle. But I cannot be at all certain as to the exact nature of this lateral appendage. It is probably homologous with the structures observed in *Cycas revoluta* and *Macrozamia spiralis* (see above).

The youngest part of the root appears to be diarch in structure.

Adult Plant.

The middle portion of a *stem*, which was from 6–8 inches in diameter, was submitted to me for investigation. It offered, however, no specially noteworthy feature in its structure. It was found to be of the type possessing but a single vascular cylinder. The only two characters of any importance are: *the incomplete cauline strand in the cortex*, and *the peduncular bundles of the pith.*

The cortex is bounded on its outermost side by periderm consisting of a narrow outer rim of cork and a very thick inner layer of phelloderm. The latter is built up of small square cells arranged in radial rows continuous with those of the cork-cells. Interspersed amongst these are branched mucilage-canals. An isolated case was observed in one part of this tissue, and nowhere else, of a curious structure of secondary character running vertically or obliquely, and consisting of two strands, each composed of short, angular, isodiametric, reticulate tracheides and thin-walled, elongated, colourless cells, all these elements being cut off by a cambium. The xylems of the two strands are directly opposed to one another, the wide parenchymatous tissue separating them being sometimes bridged by tracheides. In some places only one of these strands was present, the other having died out, leaving no trace, or its former position still traceable by a few cambial divisions in the parenchyma. An outgoing leaf-trace bundle is seen to be connected to one of these strands at one point.

All the cells of the cortex and pith are crammed full of starch-grains, which are very minute and irregularly angled. No girdle-leaf-trace bundles are seen, although these may have existed at an earlier stage of the plant's life and been subsequently cut off by the advancing periderm. All the leaf-traces observed run in a fairly direct radial direction to the central cylinder. In one place two contiguous leaf-traces running straight to the vascular ring are united by a curved connexion, which, running out from one, bends back and joins the other.

The xylem of the central cylinder forms a rather narrow zone divided up into narrow segments separated by medullary rays. The tracheides composing the wood have a very irregular course; as seen in a tangential section of the wood they bend and curve about in every conceivable direction, forming a network through whose meshes run the medullary rays. Their course appears to be far more irregular than is that of the tracheides in the stem

of *Cycas* or *Macrozamia*. All the tracheides of the secondary wood have scalariform pits, this affording a marked distinction from the two genera just cited. The protoxylem is largely obliterated; its remains are seen scattered among the pith-cells in the neighbourhood of the wood, some of the reticulate elements being still preserved in this region. There is a large amount of crushed phloem. The phloem does not attain such a relative thickness as is the case in *Cycas* or *Macrozamia,* being narrower than the xylem. It contains fibres.

In the pith are numerous branching bundles. They are seen passing into the ring all round its circumference, and they run in various directions through the pith and branch considerably. Some of the branches can be traced along medullary rays, where they eventually unite with the vascular tissues of the cylinder. There can be little doubt that these bundles belong to a peduncular cylinder traversing the pith, a fuller explanation of which will be given when describing the next genus.

The only anomaly presented by the stem of this plant is the peculiar strand of secondary tissue, composed of tracheides and parenchyma, which apparently traverses the phelloderm at the periphery of the cortex. It is highly probable that this tissue is a vestige of some former system of cauline *concentric* vascular strands characteristic of the ancestors of this plant, and I consider it probably homologous with the cortical cauline strands of *Cycas*.

Ceratozamia mexicana, *Brongn.*

A large *stem* whose apex had been destroyed, and which was otherwise rendered unfit for further cultivation, was brought into the Laboratory from the Gardens, and placed at my disposal for investigation. It had a diameter of about 8 inches. This genus also belongs to the type possessing but a single vascular cylinder. The stem, upon examination, was found to exhibit remarkably clearly *the presence of the successive peduncular cylinders of vascular tissue in the pith,* this being the only point of special interest in the whole structure. The tracheides of the outermost part of the wood of the cylinder have transversely-elongated bordered pits on their radial walls; those of the innermost part of the wood have scalariform pits. The protoxylem elements were not observed, having been destroyed during the growth and expansion of the pith-cells.

The course of the separate strands composing the cylinder is, as in all Cycads, extremely irregular and sinuous.

The cortex exhibits, in transverse section, great numbers of wedge-shaped leaf-trace bundles of various sizes and of irregular course, isolated or fusing together. In longitudinal section of a leaf-trace bundle, the tracheides are seen to have all of them scalariform pittings on their radial walls.

The wide pith contains a great number of bundles. These are seen to occur in groups or series at regular intervals upwards through the stem. Each group represents a cylinder of bundles emanating from a peduncle situated in a lateral position on the stem. Solms-Laubach* first explained in detail the whole structure, showing that the stem of a Cycad was constructed on the sympodial system (thereby confirming Karsten's and Warming's observations); the peduncle, which originally constituted the terminal portion of the stem and contained the apical meristem, finally, with the ripening of the cone, ceases its growth in length. The growth in length of the stem is continued by a lateral branch, which, arising near the base of the peduncle, by its increase in diameter and the expansion of its tissues gradually presses the latter organ to one side, enclosing its basal portion within its own tissues. In this way in an old stem a succession of peduncular cylinders comes to be embedded within the stem. The course of these was very well observed in *Ceratozamia*. The lowest of them was seen to enter the pith from the cortex in a perfectly horizontal, those higher up in a more oblique and gradually ascending, direction. As soon as the cylinder enters the pith its bundles begin to branch and spread out in all directions, eventually fusing on all sides with the cylinder of the stem. These bundles vary considerably in size and in structure. In some a cambium has formed, opposite the protoxylem, xylem and phloem with inverted orientation of parts; but the tracheides of the xylem are few in number, irregular in shape, and but slightly lignified, while the phloem is extremely rudimentary. The medullary bundles differ in shape and appearance from the leaf-traces of the cortex in the fact that the tracheidal rows of the xylem do not converge to a point so as to give the wedge-like character to the bundle, but are spreading and curved on their inner side;

* "Die Sprossfolge der *Stangeria* und der übrigen Cycadeen," Bot. Zeit. 1890.

they can thus be distinguished clearly as peduncular bundles, and not belonging to the stem in which they are found.

Numerous mucilage-canals, of irregular course, occur in both pith and cortex.

Summary.

The following are the chief facts resulting from this investigation:—

(1) Two young seedlings of *Cycas revoluta*, Thunb., show very well the general morphology of the parts at that stage: the large seed, enclosing the connate fleshy cotyledons, each of which is conduplicately folded; the insertion of the latter on the stem; the plumule with its covering of scale-leaves. The chief points in the anatomy of the seedling are: the enormous development of the *centripetal xylem* of the cotyledonary bundles, and the occurrence of anomalous rings of secondary thickening in the hypocotyl.

(2) The chief features of the anatomy of the *older seedlings* of the same plant are the following:—

The *extrafascicular strands* of secondary thickening immediately outside the central cylinder, which are collateral in structure and for the most part with the normal orientation of parts (a single weak strand in one place having, apparently, a reversed orientation of parts), these strands developing, doubtless, later into the well-known extrafascicular zones of the adult stem.

The small *concentric strands* occurring in the cortex of the stem, which are entirely of secondary origin, and correspond to the large cortical concentric strands of the adult plant.

The large obliquely outgoing strands of the hypocotyl, which run through various regions of the cortex, but whose destination and homology are doubtful; they possibly represent an effete lateral root-system.

The occurrence of *centripetal xylem* in some of the leaf-traces *in the stem*, while in some bundles in the leaf-base it has already disappeared.

(3) In the large stem of *Cycas media*, R. Br., the only feature worthy of special notice is the occurrence of *girdle-leaf-traces* in the cortex having a tendency to assume a *concentric structure* through the extension of their cambium in the form of a circle

with the protoxylem as a centre. The large, anomalous cortical strands are already known in other species of *Cycas.*

(4) The occurrence in the hypocotyl of a seedling of *Macrozamia spiralis*, Miq., of large strands passing obliquely from the central stele to the periphery, splitting into three parts as they approach the periphery of the root. These may belong to some effete system of lateral roots. The absence both of extra-fascicular zones and of a medullary system of vascular bundles in the stem. thereby affording a remarkable difference from *Macrozamia Fraseri*, Miq.

(5) The most important character of the anatomy of the *seedling* of *Stangeria paradoxa*, T. Moore, is the occurrence in the lower part of the lamina of the cotyledon, and in the stalk common to the two cotyledons, of *primary concentric bundles*, which, passing both upward and downward in the organ, gradually become collateral. This fact is probably of great phylogenetic importance.

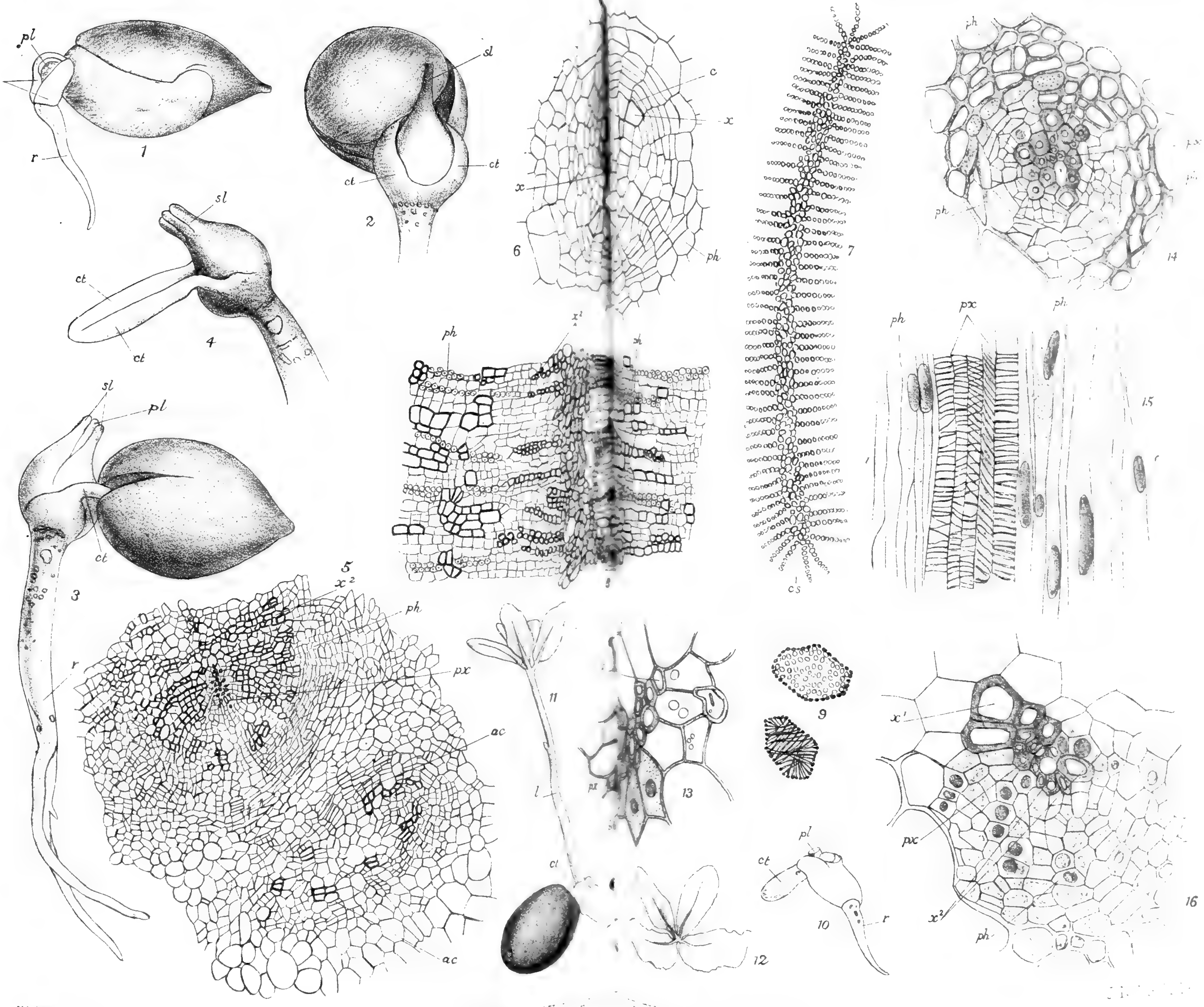
In the *root* of the seedling large, concentric strands are seen passing very obliquely outward from the central stele and entering endogenous lateral organs arising apparently from some outer layer of the cortex.

(6) The *adult stem* offers two points worthy of note: the occurrence of *peduncular bundles in the pith* which are seen passing into the central cylinder all around, whose origin and course have been fully dealt with by Solms-Laubach; the incomplete *strands of vascular tissue* in the periphery of the cortex, observed in but one isolated portion of the stem, and which probably represent an effete cauline system of concentric strands.

(7) In the large *adult stem* of *Ceratozamia mexicana*, Brongn., the *peduncular bundles of the pith* are the only characters calling for attention, whose course in the pith and origin in the peduncles can be at places observed with great clearness, thus confirming Solms-Laubach's previous investigations. Some of these bundles in the pith show a tendency to become concentric in structure, a cambium forming xylem and phloem with inverted orientation opposite the protoxylem of the bundle.

In conclusion, my best thanks are due to Dr. D. H. Scott, for his usual kind assistance and criticisms.

Worsdell



COMPARATIVE ... THE CYCADACEÆ.

EXPLANATION OF PLATE 20.

The following are the abbreviations used :—*ct*=cotyledon ; *pl*=plumule ; *sl*=scale-leaf ; *l*=leaf ; *px*=protoxylem ; x^1 =centripetal xylem ; x^2=centrifugal xylem ; *x*=xylem ; *ph*=phloem ; *c*=cambium ; *ac*=anomalous cambium ; *cs*=cortical strand ; *r*=radicle.

Cycas revoluta, Thunb.

Fig. 1. Young seedling with the cotyledons embedded in the megasporangium, the outer coat of which is partly removed. Nat. size.

2. Another view of the same. Nat. size.

3. A somewhat older seedling with the cotyledons embedded in the megasporangium, two scale-leaves enclosing the plumule, and an elongated, branched radicle. Nat. size.

4. The same with the megasporangium entirely removed, leaving the fleshy cotyledons exposed. Nat. size.

5. Transverse section of a portion of the root-stele from the hypocotyl of a young seedling, showing one of the small extra-fascicular concentric strands. ×45.

6. Transverse section of a cauline cortical strand from the stem of one of the older seedlings.

Cycas media, R. Br.

Fig. 7. Diagram of a transverse section of a cauline cortical strand at the periphery of the stem.

8. Transverse section of a portion of a cauline cortical strand. ×30.

9. Two tracheides from the central region of a cauline cortical strand. ×130.

Stangeria paradoxa, T. Moore.

Fig. 10. Seedling, with the cotyledons removed from the megaspcrangium Nat. size.

11. The same, bearing the first foliage-leaf and the cotyledons embedded in the megasporangium. Nat. size.

12. Surface view of young foliage-leaf showing the four pinnæ. Nat. size.

13. Transverse section of a collateral bundle from the upper part of the lamina of the cotyledon.

14. Transverse section of a concentric bundle from the upper part of the stalk of a cotyledon where it is still coherent with the stalk of the other cotyledon. ×390.

15. Longitudinal section of the same. ×390.

16. Transverse section of a collateral bundle from the lower part of the stalk of a cotyledon where it becomes a separate organ. ×390.

On the Occurrence of *Carex helvola*, Blytt, in Britain. By G. C. Druce, M.A., F.L.S.

[Read 3rd March, 1898.]

The first reference to the occurrence of *Carex helvola* in Britain will be found in the 'Scottish Naturalist,' vol. ii. (1885–6), p. 268, where Mr. Arthur Bennett writes that "A plant gathered by the late Prof. Balfour, on Lochnagar, on 11th August 1846, and regarded as *Carex curta* var. *alpicola*, proves to be *C. helvola*. Dr. A. Blytt has confirmed this identification." In the 'Journal of Botany' for 1886, p. 149, Mr. Bennett writes more fully:—"While examining my specimens of *Carex curta* var. '*alpicola* (Wahl.)' for the purpose of comparing them with the *C. vitilis* of Fries, I was struck with the habit of one so named [from] Lochnagar, which I received from the Edinburgh Herbarium when Mr. F. M. Webb was Curator. On dissecting a spike, and comparing with type-specimens, it seemed to agree with *C. helvola*, Blytt, although decidedly less luxuriant. I divided the specimen and sent half to Dr. Blytt, and he wrote, 'The *Carex* is no doubt *C. helvola*, though scanty; it will be well to gather it at Balfour's station.' The label runs thus:—'*Carex curta*, *β. alpicola* (Wahl.), Lochnagar, Aug. 11, 1846, Prof. J. H. Balfour.' This was three years before the description of *C. helvola* appeared in Fries's 'Nya Botanika Notiser,' for 1849."

Since the publication of this note by Mr. Bennett no further information about the plant has appeared in our British botanical publications. In the last edition of the 'London Catalogue' a query follows the census number '1,' so it would appear that Mr. Bennett was not quite satisfied as to its being a British plant. I am now enabled to give more precise particulars respecting its occurrence in Britain. The recent history of its discovery is as follows:—In 1895 the Rev. W. O. Wait of Denchworth, a well-known bryologist, told me he had recently seen *C. approximata* (*lagopina*) on Ben Lawers. I told him that, so far as I was aware, that plant was not known to occur on the Breadalbane hills and I should be glad of specimens. Unfortunately he had not collected any, but in 1896 he again visited the hill, in company with Mr. N. V. Sidgwick of Christ Church, Oxford, who I believe had been his former companion,

and they brought me some very immature specimens collected at the end of June. Scanty though these were, I was at once enabled to say they were not *C. approximata*, and I was at first inclined to refer them to montane *C. canescens*, but subsequent comparison with *C. helvola* led me to consider them to be inseparable from it. I therefore sent a specimen to Dr. Lange of Copenhagen, asking him whether he considered it to be that plant. He replied "that he thought the *Carex* must be *C. macilenta*, Fries, which he considered to be synonymous with *C. lapponica*, O. F. Lang." It is figured in the 'Flora Danica,' Suppl. iii. t. 168. Not being satisfied with this determination, I subsequently sent him a somewhat better specimen, when he replied "the young of *C. canescens* is very difficult [to determine]. There is little difference between *C. canescens*, *macilenta*, and *helvola*. Your specimen from Ben Lawers is intermediate between the two latter, possibly sooner the *C. helvola*."

As there was still an element of doubt respecting the identification, I postponed my publication of the discovery till I had obtained further information. Accordingly I went to Ben Lawers in the first week of August 1897, and aided by the description of the locality given me by the Rev. W. O. Wait and Mr. Sidgwick, after a somewhat prolonged search I found the Sedge in some abundance over a limited area, but the season being backward the specimens were not mature and the two roots I sent home both failed to produce ripe fruits. I took a type-specimen of *C. helvola* with me for comparison, and again I was unable to separate our plants from it, although our Sedge is much less luxuriant and the stems are more curved. That it was *C. macilenta* I could not myself believe. I forwarded fresh specimens to Mr. A. Bennett, who replied "that he thought I had got hold of the real thing." Subsequently I sent specimens to Dr. Christ of Basle, a well known authority on the Carices, and he replied that "The Scotch specimen is, no doubt, the true *C. helvola*, identical with the plant of Finland, Norway, and Greenland." Another specimen was sent to Professor Blytt of Christiania, who answered that "I think you may name the specimens from Ben Lawers *C. helvola*. It is not quite like the most typical form, but it is very like specimens collected by me in 1867 and which I have determined as *C. helvola*."

Prof. Blytt kindly sent me specimens collected at Landerø, the original station, and also some from the western alps of Norway which are practically identical with those from Ben Lawers.

The description of *C. helvola*, Blytt, in Fries, 'Bot. Notiser,' 1849, p. 58, as given in N. J. Andersson's 'Cyperaceæ Scandinaviæ,' p. 61 (1849), is as follows :—"Spica composita, spiculis sub-quinis, linearibus, confertis (disticho-imbricatis), conformibus, terminali basi mascula; bracteis glumiformibus, brevissimis; fructibus ovato-oblongis, in rostrum compressum sub-bidentatum attenuatis, plano-convexis, enervibus, squamas ovatas acutas æquantibus; foliis planiusculis.

"Radice, culmo, colore et habitu priori [*C. microstachyæ*] tam simillima, ut vix distinctum diceres; sed differt: radice densius cæspitosa, foliis latioribus (1–1½ lin.), planis, marg. demum subrevolutis, spicis omnibus æqualibus (terminali sc. ceteris non majori, lineari, nec ad maximam partem v. tota mascula) longioribus, excurvatis (in formam *C. brizoidis*), pallide fulvis.

"Haec planta memorabilis videtur, utpote locum in systemate *C. microstachyæ* optime indicans. Cum ea specie enim arctissime conjuncta, habitu tamen et characteribus singulis *C. heleonastem*, *norvegicam*, et *vitilem* quodammodo refert. A *C. heleonaste* foliis fructibusque ore distincte bidentulo terminatis, a *C. norvegica* fructibus plano-convexis, rostratis, et a *C. vitili* squamis longioribus, fructibus lævibus non bifidis &c diversa."

It is figured in the 'Flora Danica,' Suppl. i. t. 32.

In appearance our plant strongly resembles montane forms of *C. canescens*, to which plant I consider it closely allied. The chief differences are the darker and more cylindrical spikelets, the longer glumes, and the more bluish-green foliage. Our lowland *C. canescens* has distinctly yellowish-green leaves. The Scottish *C. helvola* has a different habit, for instead of the upright growth of the lowland *C. canescens*, the stems slant outwards and are uniformly curved, in a manner somewhat similar to fruiting *C. pilulifera*. The chief difference is, however, to be found in the perigynium, which in *C. canescens*, even in its montane forms, is distinctly ribbed, but is smooth or nerveless in the Ben Lawers and in the Scandinavian plants. How far this is due to the immature or barren condition of the fruit, I am unable to say. The texture of the perigynium when examined under a lens is somewhat different, the tissue

being laxer and having the appearance of being punctulate. Hitherto I have been unable to find mature fruit of *C. helvola*, either in the many specimens which I have examined from Norway or from Ben Lawers, but even in young *C. canescens* from Berkshire the ribs on the perigynium can be observed. The perigynia are also somewhat shorter than in *C. canescens*, and are more oblong in shape than the perigynia of a closely allied plant issued in the "Herbarium Normale" of Schultz and Dörfler (n. 3289) and named *Carex Zahnii* [*C. approximata* × *Persoonii*], Kneucker in 'Deutsche Botan. Monatsschrift,' ix. (1891) p. 60, which has been found on the ascent of the Grimsel growing with both its assumed parents. In this plant the perigynia are abruptly narrowed at both the base and the apex so as to give it a skate-like appearance, and there is more brownish coloration than in our *C. helvola*. In external appearance *C. Zahnii* bears a closer resemblance to our *C. helvola* than that plant does to the Scandinavian *C. helvola* collected by G. Blytt in Landers; indeed from outward appearance *C. Zahnii* could scarcely be distinguished from our *C. helvola*, but the shape of the sterile fruit differs as I have said considerably. I do not lay great stress upon the shape of immature and sterile perigynia.

Another plant which bears a close superficial resemblance to our *C. helvola* is *C. pseudohelvola* (*C. canescens* × *norvegica*), Kihlm. in Herb. Mus. Fenn. ed. ii. p. 125–6, issued in the same "Herbarium Normale" (n. 3095) and coming from arctic Norway; but in this plant the perigynia are distinctly ribbed, the spikes more compact, and the spikelets arranged in the manner characteristic of the Cyperaceæ, while in our plant they have a spuriously distichous arrangement, the spike having a flattened appearance.

The question may be asked, Is *C. helvola* a good species? Against this supposition may be urged the uniform sterility, seeing, as I have said, that in the many Scandinavian and Scottish specimens which I have examined I have not been able to find a mature fruit. Is it then a hybrid or a sterile form? If a hybrid, I should have no difficulty in suggesting *C. canescens* as one of the parents, but should have great hesitation in naming the other. Dr. Christ has replied to my query: "J'ai toujours pensé que le *C. helvola* de Blytt est une de ces espèces qui doivent leur origine à deux plantes, et ces plantes

ne devaient être que *C. lagopina* (*approximata*) d'un côté, et *echinata* ou *Persoonii* d'un autre côté. *C. helvola* me semble être un ancien hybride devenue fixe, et plus ou moins stable, et il n'est pas invraisemblable qu'il se présente sous quelques formes légèrement différentes. De ce point de vue il doit être extrêmement difficile de distinguer le *C. helvola* de nouveaux hybrides entre les dites espèces."

I may add that the Rev. E. F. Linton has examined the Ben Lawers plant, and considers it to be *C. canescens* × *echinata*. In support of this view of the origin of our Sedge is the occurrence of *C. echinata* in great abundance in the locality. But if this be the origin, we ought to see some evidence of the presence of *C. echinata* in our plant. We have seen that the offspring of *C. norvegica* and *canescens* is a plant with strongly ribbed perigynia. Should we not expect then to see traces of ribs on the perigynia of the offspring of two parents each possessing ribbed perigynia? I can see nothing in the shape of the fruit of our plant, in its arrangement, or in its veining which suggest the presence of *C. echinata*. Again we might expect, if that suggestion be correct, to find plants approaching to one or the other of the assumed parents. I carefully looked out for such specimens but did not see any. Indeed *C. helvola* on Ben Lawers was singularly unvarying in appearance, being much more constant in character than *C. flava* or *C. saxatilis* which grew near. At the altitude where the plant occurred, *C. echinata* was in flower while *C. canescens* was fruiting. From the very close superficial resemblance borne to our plant by *C. Zahnii*, the suggestion that *C. approximata* is the other parent is perhaps more probable. Against this origin of the Ben Lawers Sedge is the fact that the occurrence of *C. approximata* in the Breadalbane range of hills has never yet been proved. The nearest observed locality of *C. approximata* is Cairntoul, which must be fifty miles to the north-east, and consequently against the prevailing wind during the flowering season. It may be that formerly *C. approximata* occurred in the neighbourhood, but again undoubted offspring of *C. Persoonii* and *C. approximata* are different in shape from those of our Scottish plant. I by no means assert that *C. helvola* (which may be an analogous plant to *Salix Smithiana*) is not the offspring of *C. canescens* in one of its mountain forms with either *C. echinata* or *C. approximata*, but I fail to see

positive evidence of the former, and in the case of the latter the probable absence of one of the assumed parents is a difficulty which appears almost insuperable.

I shall content myself with remarking that I cannot separate the Ben Lawers plant from *C. helvola*, Blytt, and shall leave more experienced workers to decide upon its origin.

C. helvola is kept as a distinct species in the 'Index Kewensis,' Richter's 'Plantæ Europææ,' and Nyman's 'Conspectus Floræ Europææ.' In the List of European Carices which appeared in the 'Comptes-rendus' of the Société Royale de Botanique de Belgique, vol. xxiv. pt. 2, pp. 10–20, from the pen of Dr. H. Christ, it is also given specific rank, but a note is added "an *C. microstachya-canescens*? Boeckeler, Linnæa, 1875, p. 133." Dr. Christ places it in the Section 31. Lagopinæ of Nyman, thus widely separating it from Section 28 which contains *C. canescens*. Under *C. canescens* he groups *C. vitilis*, *C. Persoonii*, *C. canescens* var. *subloliacea*, Laestad., and *C. macilenta*. Nyman also separates the two plants widely—*C. helvola* being no. 108 in Section C. Heterostachyæ distigmaticæ mucronatæ, while *C. canescens* no. 125 is in Section E. Homostachyæ hyparrhenæ canescentes. To me the grouping would appear more natural if the Lagopinæ followed the Canescentes. At any rate the separation of *C. helvola* from *C. canescens* appears to be untenable. The distribution of *C. helvola* as given in Nyman's Conspectus is "Norv. Suec. bor., med. Fenn. mer. Siles. (r.). Tyrol. (r.)."

It is possible that the Silesian and Tyrolean specimens might more correctly be referred to *C. Zahnii*.

The station of *C. helvola* on Ben Lawers, where it is frequent over a limited area, is a micaceous bog made by a small mountain stream, which has broadened out one of the flatter terraces on the eastern side of the mountain, at an altitude of about 3000 feet. *C. echinata* grows plentifully with it, and *C. flava* and *C. saxatilis* are in the same neighbourhood. In a similar bog about 200 feet below, montane *C. canescens* occurred (this has nearly the same habit as *C. helvola*), but I did not observe it growing with *C. helvola*, nor at higher positions on the eastern side. On the western side of Ben Lawers I found a few plants of *C. helvola* at a higher level, probably over 3400 feet. and on this side some quantity of a form of *C. canescens* (var. *robusta*, Blytt), which by some British botanists would be

named *C. alpicola*, Wahl., grew in an equally elevated situation. This dispelled the thought that had been in my mind that *C. helvola* was only a sterile form of *C. canescens* caused by growing at so great an altitude. I hope the specimen which Mr. B. S. Ogle is cultivating for me may, when mature, throw some additional light upon the subject.

In conclusion I may say that in 1896 I made an unsuccessful search for *C. helvola* on Loch-na-gar, but I had so little time at my disposal that I was unable to examine the southern slope, where in the eighties I remember seeing mountain forms of *C. canescens*. Pfarrer Kükenthal has recently seen our *C. helvola* and considers it to be *canescens* × *lagopina*.

On *Limnocarpus*, a new Genus of Fossil Plants from the Tertiary Deposits of Hampshire. By CLEMENT REID, F.L.S., F.G.S.*

[Read 17th March, 1898.]

WHILE engaged on the Geological Survey of Hampshire during the last ten years, I have found abundance of a fruit closely allied to *Potamogeton* and to *Ruppia*, though differing materially from those genera. As no generic description appears to have been published, and this seems to be one of the rare cases in which a Tertiary plant can be shown to belong to a generic type now extinct, I have delayed publishing the new genus until further material could be obtained and some doubtful points could be cleared up.

No description can yet be given of any part of the plant except the fruit, though the type species seems to have had linear leaves like those of *Ruppia* or of many species of *Potamogeton*. Leaves of this character occur in certain seams of loam in the Lower Headon Beds containing no fruits except those of *Limnocarpus*.

LIMNOCARPUS, genus novum e Naiadacearum.

Fructus succulentus? Carpella 2, pedicellata, sese marginibus ventralibus adherentia: endocarpium durum, a tergo carinatum, admodum foveatum, rugosum: rostrum productum. Semen circa loculi processum curvatum, testa coriacea.

Species unica, herbæ aquaticæ.

Accedit *Potamogetono* sed ab eo carpellis 2 nec 4 discrepat.

* By permission of the Director-General of the Geological Survey.

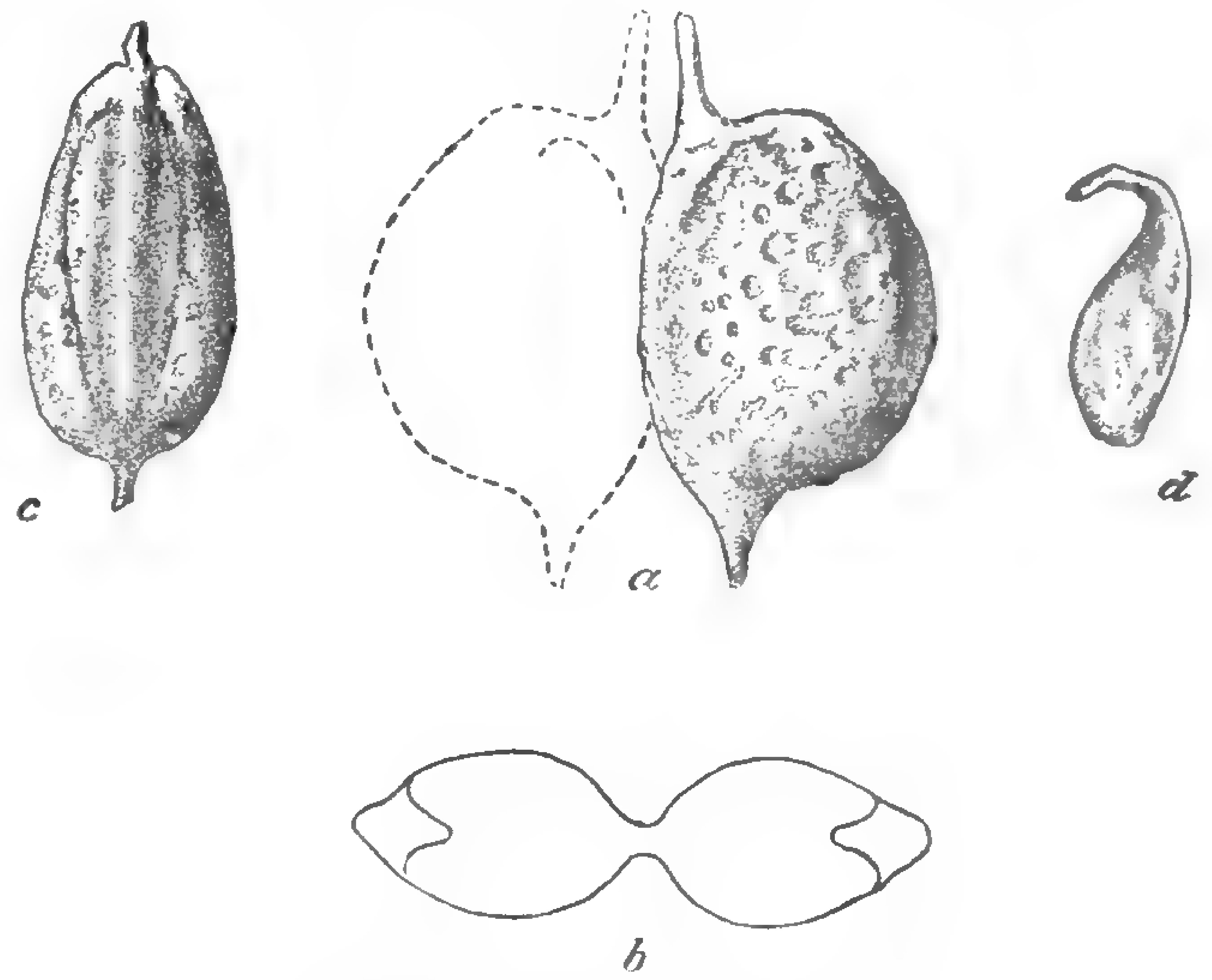
Aquatic herbs; fruit succulent? Carpels two; endocarp hard, dorsally keeled, deeply pitted and wrinkled, adhering by the ventral margin, stalked; beak elongated; seed curved round a process from the cell, testa coriaceous.

LIMNOCARPUS HEADONENSIS, *nobis*.

SYN. *Carpolithes headonensis*, J. S. Gardner in Rep. Brit. Assoc. 1887, pp. 420, 421, pl. 3. fig. 30.

Endocarp 2 mm. long by 1·5 mm. broad, inflated, laterally compressed, deeply pitted; a large oval oblique pit on the side corresponds with the internal process round which the seed is curved; pedicels converging, about $\frac{1}{3}$ the length of the endocarp; beak slender, parallel, about $\frac{1}{2}$ the length of the endocarp.

The fruit resembles that of *Potamogeton*, but is distinguished by the carpels being adherent, 2 instead of 4, and by the pitted



Limnocarpus headonensis.

a. Endocarp, side view, the second carpel shown by dotted line. *b.* Transverse section through fruit. *c.* Endocarp of another specimen, dorsal view. *d.* Seed somewhat shrivelled, from another specimen. All magnified 10 diameters.

endocarp with long slender stalk and beak. These characters probably indicate that the two carpels were buried in a succulent exocarp; for pitted endocarps usually belong to fleshy fruits, and the convergence of the stalks would scarcely bring the carpels together edge to edge, unless they were already in some way connected. Most of the endocarps are found detached, but I have now seen six specimens in which the ripe endocarps adhere by their narrow ventral edge.* The inflation of the

* The attachment is often so slight that several fruits have divided in the attempt to remove the adhering sand.

endocarp, and the absence of any trace of lateral pressure or facetting in any of the specimens examined, show that the carpels cannot have exceeded two. In germination the keel becomes detached, and is therefore missing in many specimens.

The genus occurs in brackish-water deposits throughout the Oligocene strata of the Hampshire Basin. The type-specimens are from the Lower Headon beds of Hordle cliff, the same species ranging upwards into the Hamstead series. Badly preserved endocarps, perhaps belonging to another species of the genus, or to *Potamogeton*, occur in the Mead End beds, at the top of the Barton Sands.

In 1862 Heer described * as *Cyperites Forbesii* some fruits from the Hamstead beds. His figures are not satisfactory; and the types cannot be recognized in the Burdett-Coutts collection, now in the Museum of Practical Geology, which he used, though several slabs of clay full of seeds, apparently named by Heer *Cyperites Forbesii*, are there †. Heer's reference of the fruits to Cyperaceæ, suggestion that they may be the unknown fruits of *Cyperus reticulatus*, and description, which in nearly every particular is unlike that of the genus *Limnocarpus*, may make it seem absurd to suggest that he has been mistaken. His remark, however, that they occur in "great numbers together in the upper three feet of the third division [of the Hamstead Series] of Edward Forbes" is curious, for all the recognizable specimens on the slabs in the Museum of Practical Geology belong to *Limnocarpus*, too badly preserved for specific determination, though perhaps representing only a smaller variety of *L. headonensis*. There is nothing in the collection that I can refer to Cyperaceæ, though some of the crushed and distorted specimens seem to resemble Heer's figures. Mr. E. T. Newton and I think that in all probability a mistake has been made, and that through describing badly preserved specimens Heer missed the essential characters. If such be the case, Heer's species must be deleted, being so described and figured as to be quite unrecognizable. Perhaps, however, the real *Cyperites Forbesii* may have found its way into some other collection, for several plants figured on the same plate cannot at present be traced.

* Quart. Journ. Geol. Soc. vol. xviii. p. 373, pl. xviii. figs. 20 & 21.

† Similar fruits have been figured by J. S. Gardner also as *Cyperites Forbesii*, *op. cit.* fig. 16.

On the Structure and Development of *Dendroceros*, Nees. By

DOUGLAS HOUGHTON CAMPBELL, F.M.L.S., Professor of Botany, Stanford University, California.

(PLATES 21 & 22.)

[Read 21st April, 1898.]

THE Anthocerotaceæ stand very much alone, and their affinities with the other Archegoniates have given rise to much discussion. All the members of the order agree closely in the character of the sexual organs and sporophyte, which differ much from those of the other Hepaticæ, and the single chromatophore in each cell of the thallus is a peculiarity which they share with no other Muscineæ, but in which they rather resemble certain Algæ.

There are three well-marked genera of the Anthocerotaceæ which, while differing from each other in certain minor particulars, are obviously closely related among themselves, but show no very clear evidences of relationship with any other Hepaticæ. These genera are *Notothylas*, Sulliv., *Dendroceros*, Nees, and *Anthoceros*, Mich. The latter genus includes the greater number of species and is widely distributed throughout temperate and tropical regions; *Notothylas*, with a much smaller number of species, seems to belong mainly to the temperate zones; while *Dendroceros* is exclusively tropical in its range.

Anthoceros, being widely distributed in Europe, has been the subject of repeated investigations; and *Notothylas* has been studied by Leitgeb *, to whose researches on the Liverworts so much of our present knowledge of these plants is due. More recently the development of this plant has been studied by Mottier †, and the present writer has considered this genus as well as *Anthoceros* in a recent work ‡. Practically the only account of *Dendroceros* which is in any way complete is that given by Leitgeb in the work already referred to. While this observer was able to make out an amount of detail which is really astonishing considering that he had herbarium-material only at his disposal, which comprised little except mature plants, there were a number of important points which his imperfect material obliged

* H. Leitgeb, Untersuchungen über die Lebermoose, Heft 5.

† D. M. Mottier, "Contributions to the Life-History of *Notothylas*," Annals of Botany, viii. Dec. 1894.

‡ D. H. Campbell, Structure and Development of Mosses and Ferns: Macmillan, 1895.

him to leave incomplete, and it was with the hope of clearing these up, as far as possible, that the present work was undertaken.

During a visit to Jamaica in the summer of 1897, *Dendroceros* was met with several times, and an abundant supply of material, preserved in chromic acid and in alcohol, was procured. Examination of this showed that all stages of development were present, and although the study made was hardly an exhaustive one, it is believed that the most important gaps left by Leitgeb's investigations have been filled.

The common species, to judge from a comparison with Leitgeb's description of the genus, was *D. Breutelii*, Nees, but a second species, possibly *D. crispus*, Nees, occurred growing with the first. As the two are much alike in appearance it was supposed that we had only one species, and it was not until the investigation of the ripe sporogonium was made that the error was discovered. It was therefore impossible to decide from which species some of the preparations were made, as they seem to agree almost exactly in everything except the character of the spores and the cells of the sporogonium-wall.

All the species of *Dendroceros* are epiphytes, in this respect differing from the other genera, which are mainly terrestrial. They grow upon the stems and twigs of small trees and shrubs, near the ground, and also may cover the upper surface of the leaves. Most of the specimens were collected at an altitude of between 1000 and 2000 feet, where the precipitation was very heavy and the tropical conditions pronounced. Most of my material was procured in the mountains south of Port Antonio on the road to the Cuna Cuna Pass. Here the plants occurred in great profusion, covering the stems and lower twigs of a number of shrubs, especially a species of *Eugenia*, probably the common Rose-apple, *E. Jambos*, Linn. In this case the broad evergreen leaves were often almost covered with the *Dendroceros* and other epiphytic hepatics.

The thallus of *Dendroceros* is at once distinguished from that of the other Anthocerotaceæ by the possession of a definite midrib, with a more or less lobed lamina on either side. It looks quite like a *Fossombronia* in habit, but the microscope at once reveals the single chloroplast in each cell, so that even when sterile the plant is unmistakable.

The sporogonia are produced freely, but are not so numerous

as those produced in certain species of *Anthoceros* and *Notothylas*. In size they are intermediate between these, seldom exceeding one or two centimetres in length. Like all the other Anthocerotaceæ, the thallus always contains colonies of *Nostoc*, which are here very conspicuous and form large globular swellings upon the upper side of the thallus, close to the midrib.

The thallus in all the described species of *Dendroceros* agrees in having a well-defined midrib and thin lateral lamina. In *D. Breutelii* the midrib shows no intercellular spaces, but small ones occur between the cells of the lamina. Certain species, however, like *D. javanicus*, Nees, have large lacunæ in the midrib, whose surface presents an areolated appearance like that of the Marchantiaceæ*. Similar lacunæ occur in the thallus of *Notothylas orbicularis*, Sulliv., and some species of *Anthoceros*.

The apical growth of the thallus of *D. Breutelii* has been studied by Leitgeb †, and his account agrees in the main with my own, although there are one or two points of difference. A vertical longitudinal section (Pl. 21. fig. 1) presents the same appearances found in most fern-prothallia and in *Pellia epiphylla*, Corda. The large apical cell appears semicircular and extends the whole depth of the thallus, and the segments cut off from its inner face extend also completely from the dorsal to the ventral surface. Horizontal sections (figs. 2, 3) show at the apex one or two nearly oblong cells, and while it is probable that usually, at least, there is but one initial cell, it is possible that there may be more. In the form of the apical cell *Dendroceros* differs both from *Notothylas* and *Anthoceros*, where two sets of basal segments, alternately dorsal and ventral, are found, instead of the single one found in *Dendroceros*.

Each primary basal segment of the apical cell in *Dendroceros* (fig. 1) is first divided into two equal cells by a median longitudinal wall, thus forming a dorsal and ventral semi-segment. Each of these is next divided by a vertical wall parallel to the base of the apical cell, so that the whole segment is now divided into four similar cells, two dorsal and two ventral. Leitgeb's figure ‡ does not show the formation of vertical walls until a much later period, the second walls in the segment being represented as horizontal. In all the preparations examined by the writer, the horizontal walls only arose after one set of

* Leitgeb, Unters. üb. Lebermoose, Heft 5, p. 30. † *L. c.* p. 30.

‡ Leitgeb, *l. c.* pl. 2. fig. 1.

vertical ones had been formed. As soon as the horizontal walls are formed in the dorsal and ventral cells the midrib becomes four cells thick, and later horizontal walls make it much thicker farther back from the apex. As the alternation of vertical and horizontal walls is quite regular for some time, the limits of the original segments can be traced for a considerable distance back from the apex. Besides the basal segments, which contribute mainly to the formation of the midrib, there are also formed lateral segments which remain undivided by horizontal walls, and give rise to the thin lamina.

The formation of the "stomata" or mucilage-slits upon the thallus was not studied in detail, as Leitgeb has given a full and accurate account of these structures, which agree in all particulars with the similar ones in *Anthoceros*. As in *Anthoceros*, these are always associated with the formation of the conspicuous *Nostoc*-colonies, the filaments entering the thallus through the mucilage-slits.

The Sexual Organs.

All the species of *Dendroceros* examined are monœcious, and there is no evident regularity in the occurrence of antheridia and archegonia, except that as a rule several of one or the other are formed in succession. As in all the Anthocerotaceæ, they are sunk in the thallus and are very inconspicuous, except in the case of the older antheridia, which in *Dendroceros* are very much larger than in either *Anthoceros* or *Notothylas*.

Leitgeb gives a brief account of the archegonium, but there are several points worthy of note which he seems to have overlooked. As the young archegonium is completely immersed in the thallus, and the mother-cell hardly distinguishable from the surrounding tissue, it is not possible to assert positively its exact relation to the segment of the apical cell in which it is formed. The walls by which it is cut out, seen in transverse section, intersect so as to enclose a triangular cell, as was shown by Leitgeb, and in this respect it agrees with the other Anthocerotaceæ. This cell then by transverse divisions (fig. 5) gives rise to the axial row of three cells, found in the young archegonium. The lower cell, by a subsequent division, gives rise to the egg-cell and ventral canal-cell; the middle one, by a series of transverse walls, produces the row of four or five neck-canal-cells; while the upper one, by two intersecting vertical walls, forms the four cover-cells, or, by the suppression of one of the walls, but

two cover-cells are formed. When the archegonium is ripe, its apex is raised slightly above the general level of the thallus.

If we compare the archegonium of *Dendroceros* with that of *Notothylas* and *Anthoceros,* it is found to be to a certain extent intermediate in character. The primary axial cell is broader than that of the latter, but not so broad as that of *Notothylas,* and the same is true of the primary neck-canal-cell.

As in the other genera, the egg-cell does not fill the cavity of the venter. At maturity the archegonium opens and the cover-cells of the neck are usually thrown off, while the cells below them diverge more or less.

The Antheridium.

The antheridium of *Dendroceros* differs a good deal from that of the other Anthocerotaceæ, being much larger, solitary, and having a long pedicel, while in most species of *Anthoceros* and *Notothylas* the antheridia are short-stalked and occur in groups formed from the division of a common mother-cell.

Owing to the very incomplete account of the antheridium given by Leitgeb, its development was followed with some care. As was shown by Hofmeister *, and later confirmed by Leitgeb and others, the Anthocerotaceæ differ from all other Hepaticæ in the endogenous origin of the antheridium. In all of them it arises from a sub-epidermal cell, which either develops at once into a single antheridium or, more commonly, divides into a number of cells, each of which produces an antheridium.

In *Dendroceros* the antheridia are formed in strict acropetal succession, the youngest ones being found very near the apex. They are arranged in two lines, one on either side of the midrib. The mother-cell cannot be certainly distinguished until it begins to separate from the adjacent cells, when it is readily recognized, as the space about it is lined with a mucilaginous matter derived from the partially disintegrated cell-walls, which stains very strongly with Bismarck-brown or hæmatoxylin. The first division in the superficial cell by which the antheridial cell is cut off occurs in the second or third segment from the apex of the shoot, and the result of this division is the formation of two cells, an outer and an inner one, of which the latter becomes at once the mother-cell of the single antheridium. A second transverse wall makes its appearance very early in the

* Hofmeister, "The Higher Cryptogamia," Ray Soc. 1862, p. 7.

outer cell, so that the young antheridium is separated from the surface of the thallus bv two layers of cells (fig. 7). About the same time, by a partial disintegration of the surrounding cell-walls, the young antheridium becomes separated from the adjacent cells except at one point, which becomes the point of attachment for the pedicel. By the rapid growth of the surrounding tissue, the space about the antheridium becomes rapidly larger and very conspicuous (Pl. 21. fig. 8).

In all the youngest stages observed, the antheridial cell was decidedly elongated parallel with the axis of the shoot, instead of vertically as is the case in *Anthoceros* and *Notothylas*, and the point of attachment is at the back of the cavity in which it lies, instead of at the bottom. Consequently the young antheridium (Pl. 21. fig. 8) lies almost horizontally instead of standing upright.

In both *Anthoceros* and *Notothylas* the first division in the primary antheridial cell is vertical, and is usually followed by a second vertical wall at right angles to the first, so that four similar cells are formed which give rise to as many antheridia. In *Dendroceros*, however, the original cell, as we have seen, forms but a single antheridium.

In *Anthoceros* each secondary antheridial cell divides precisely as did the original one, into four, by intersecting vertical walls, after which a transverse wall is formed in each cell, which separates a stalk-cell from the body of the antheridium. The divisions in *Notothylas* are similar, but less constant, as sometimes the separation of the stalk may be effected by the first wall formed in the antheridial cell.

In *Dendroceros*, to judge from the small number of the very early stages available for study, the first wall (Pl. 21. fig. 7) separates the stalk from the body of the antheridium, after which two intersecting longitudinal walls arise in each of the primary cells, by which they are divided into four equal cells. In the stalk one of these walls may be suppressed, and the stalk remains in consequence composed of but two rows of cells, as Leitgeb describes *, but where both are formed, a cross-section of the stalk shows four cells arranged quadrant-wise (fig. 10).

The divisions in the upper part of the antheridium resemble those in *Anthoceros*. Each cell is first divided by a transverse wall (Pl. 21. fig. 8) into two, of which the one next the stalk is the smaller and contributes to the basal part of the antheridium-

* Unters. üb. Lebermoose, Heft 5, p. 33.

wall; this is followed by a second transverse wall in each of the terminal cells, and in each of the resulting eight cells there then is formed a periclinal dividing it into an inner and an outer cell (fig. 9). The inner cells, by rapid divisions in three planes, give rise to the central mass of small, nearly cubical sperm-cells, while the outer layer of cells divides no further by periclinals, but remains permanently but a single cell in thickness. Each of these outer cells contains a single chloroplast as in the other genera. There is very little displacement of the cell-walls in the inner mass of sperm-cells, and these are arranged in nearly cubical masses, corresponding to the early divisions in the central cells (fig. 12).

The sperm-cells are too small to make possible a satisfactory study of the spermatozoids, and as there was no indication of any variation from the type of structure found in the other Hepaticæ, no attempt was made to trace the development of the spermatozoids. The latter are small, but were not studied in the living material owing to lack of facilities when the material was collected.

The ripe antheridium, as Leitgeb showed, is very large and the stalk extremely long so that it is coiled up within the cavity containing the antheridium. The upper wall of the cavity projects strongly above the surface of the thallus, forming a nearly globular protuberance easily seen with the naked eye, and resembling the similar swellings caused by the *Nostoc*-colonies.

The Sporophyte.

As might be expected, from its intermediate character in other respects, the sporogonium of *Dendroceros* is also, to a certain extent, intermediate in structure between that of *Notothylas* and *Anthoceros*. The structure of the sporogonium in the former genus has been studied by Mottier *, whose results agree with those of the writer made upon the same genus, and do not confirm Leitgeb's contention † that the origin of the columella may be secondary, but show that, as in *Anthoceros*, the columella is formed by the first periclinals in the upper cells of the embryo. In *Notothylas*, as in most Hepaticæ, the first wall in the embryo is transverse and divides the embryo into nearly equal parts in which longitudinal walls then arise, dividing the embryo

* D. M. Mottier, in Ann. Bot., viii. Dec. 1894.

† Leitgeb, Unters. üb. Lebermoose, Heft 5, p. 7.

into nearly equal octants, as in the Marchantiaceæ. In *Anthoceros* (at least in *A. fusiformis*, Mont., which was specially investigated by the writer *), the first wall in the embryo is vertical, and is followed by a transverse wall in each cell, the resulting cells being of very unequal size. (See 'Mosses and Ferns,' fig. 59.)

The youngest embryo met with in *Dendroceros* is shown in Pl. 22. fig. 13. The arrangement of the walls indicated that the primary wall here is longitudinal, as in *Anthoceros*, but the first transverse wall is nearly median, and the lower cells are thus decidedly larger than in the latter genus, and it seems probable that the foot is determined by this first transverse division, as in *Notothylas*, and does not involve the second tier of cells as is the case in *Anthoceros*. All three genera agree in having the embryo in this stage made up of three tiers of cells, each composed of four cells arranged quadrant-wise in cross-section (figs. 13, 15).

The next divisions in each of these three tiers separate four central cells (endothecium) from usually eight peripheral ones (amphithecium) (Pl. 22. fig. 16). In *Dendroceros*, as in all the Anthocerotaceæ, it is from the amphithecium that the archesporium develops, the whole of the endothecium in the upper segments of the embryo going to form the columella. The archesporium is determined by the first set of periclinals in the amphithecial cells, and at first forms a single layer of cells extending over the columella and reaching to the base of the middle one of the three primary segments of the embryo (Pl. 22. fig. 14). In this respect *Dendroceros* differs markedly from *Anthoceros*, where the formation of the archesporial cells is confined to the terminal segments (see fig. 60 in 'Mosses and Ferns'). Leitgeb's figure of an embryo of *Dendroceros* (Heft 5, pl. 3. fig. 10) agrees closely with Pl. 22. fig. 14, given here. In *Notothylas* there is usually a zone of tissue between the foot and capsule in which the archesporium cannot be made out, and it is not impossible that this may also be the case, sometimes, in *Dendroceros*.

In regard to the development of the sporogenous tissue, *Dendroceros* is the most reduced genus of the order. While in *Notothylas* the archesporium becomes very massive, being three or four cells in thickness, and in *Anthoceros* regularly two cells thick, in *Dendroceros* the periclinal walls in the archesporium are very irregular and may, at certain points, be completely

* Campbell, 'Mosses and Ferns,' pp. 127–136.

suppressed, so that it remains permanently but one cell thick. The arrangement of the sporogenous and sterile cells, too, is much less definite than in the other genera. Occasionally (Pl. **22.** fig. 17) there is a fairly regular alternation of sporogenous and elater-cells, determined sometimes by oblique divisions of the primary archesporial cells into two of unequal size, the larger one becoming the sporogenous cell, the other, one member of an elater. Quite as often, however, some of the primary cells remain undivided and, enlarging rapidly, form at once the mother-cells of the spores. The others divide once longitudinally, and become elater-cells.

The columella in the forms examined by me corresponds very closely in the arrangement of the cells to that of *Anthoceros*, showing in cross-section (Pl. **22.** fig. 18) usually sixteen cells arranged very regularly. As in *Anthoceros*, these cells later separate somewhat, showing intercellular spaces at the angles. Leitgeb's figures of *D. cichoraceus* show a more massive columella and a relatively slight development of the amphithecium.

Each sporogenous cell gives rise to four tetrahedral spores in the usual manner. These spores are much larger than in the other genera, and may remain undivided until the dehiscence of the sporogonium (*D. Breutelii*), but in the second species examined (probably *D. crispus*, Nees) the spores germinate within the capsule and become multicellular bodies of considerable size before they escape. Leitgeb records similar multicellular spores in several other species, e. g., *D. crassinervis*, Lehm. & Lindenb., *D. cichoraceus*, Lehm. & Lindenb., and states that in the latter species both unicellular and multicellular spores are found. He infers, and probably with reason, that the multicellular spores are simply accelerated phases of germination such as occur in *Pellia*. In the cases observed by the writer where multicellular spores occurred, all the older spores showed this condition, and all the spores of a tetrad developed perfectly, there being no such abortion of two of the spores of the tetrad as Leitgeb describes and figures.

As already indicated, no constant relation between sporogenous and elater-cells can be made out. The elaters, as is well known, are not single cells, but are composed of two or three cells joined end to end. There is no indication that the primary elater-cells undergo further transverse division, but the fully-developed elater is composed of several of these primary elater-cells which simply cohere, as is the case in *Anthoceros*.

The single broad spiral band developed upon the wall of the elater seems to be a constant characteristic of the genus. The fully-developed elaters are packed in between the spores, and in stained sections are very conspicuous on account of the strongly stained spiral (fig. 19, *el.*).

The outer cells of the capsule become much thickened at maturity, but differ a good deal in the two species examined. In *D. Breutelii* the cells were elongated with the lateral walls uniformly thickened. In *D. crispus* (?) they were shorter and the corners were thickened, so that they presented almost the appearance of typical collenchyma-cells.

The dehiscence of the capsule is usually by two valves, as in *Anthoceros*, but sometimes there was a split on one side only. No stomata were observed in any instance, thus agreeing with Leitgeb's conclusions as to their complete absence in *Dendroceros.*

Summary and Conclusions.

1. In its apical growth and the form of the thallus *Dendroceros* differs decidedly from the other genera of the order. The type of apical cell is that found in *Pellia epiphylla* and in the homosporous Ferns, especially *Osmunda*, where the prothallium resembles the thallus of *Dendroceros* also in the definite midrib and the occasional development of leaf-like lobes. The occurrence of abnormally large chloroplasts has been observed by the writer in *O. cinnamomea*, and may indicate a real relationship with forms like *Dendroceros.*

2. The archegonium corresponds in its structure to that of the other Anthocerotaceæ, and is intermediate in character between *Notothylas* and *Anthoceros.*

3. The antheridium is solitary and arises, as in the other members of the order, endogenously. The separation of the pedicel is determined by the first division-wall in the young antheridium, and in this respect is more like that of *Notothylas* than *Anthoceros*, where this first arises after two longitudinal walls have been formed. The stalk may have either two or four rows of cells.

4. The first wall in the embryo is longitudinal, as in *Anthoceros*, but the first transverse wall determines the limits of the foot, as in *Notothylas.*

5. The origin of the archesporium is from the amphithecium as in the other two genera, but it is less massive than in either of

these. The archesporium can be traced to the boundary between the foot and capsule, and resembles in this particular *Notothylas* rather than *Anthoceros*.

6. The division of the archesporial cells into sporogenous and sterile ones is less regular than in either of the other genera, and the primary archesporial cells may be transformed directly into sporogenous ones without any further divisions. The elaters are composed of two or more cells and have a thickened spiral band.

7. In *D. Breutelii* the spores remain undivided, but in *D. crispus* (?) they germinate within the capsule and are discharged as multicellular bodies. All the spores of a tetrad develop normally, and there is no abortion of a part of them, as described by Leitgeb for *D. cichoraceus*.

8. Leitgeb's statement as to the absence of stomata from the capsule was confirmed.

Dendroceros is unquestionably closely related to *Anthoceros*, from which it differs principally in the form of the thallus and the less highly developed sporophyte. Leitgeb * concludes that the division of the genus *Anthoceros* which includes *A. vincentianus*, *A. giganteus*, and others is perhaps more nearly related to *Dendroceros* than to the other species of *Anthoceros*, and suggests a separation of this section as a distinct genus. These forms have no stomata upon the capsule, and possess spiral elaters like those of *Dendroceros*. A careful comparison of these with *Dendroceros* would be interesting, to see how far they agree in other respects with it. Leitgeb cites one species, probably *A. vincentianus*, which has a solitary antheridium; and a comparison of the apical cell and archegonium might throw light upon the relation of these forms to *Dendroceros*.

In the form of the archegonium, as well the early stages of the embryo, *Dendroceros* is fairly intermediate between *Notothylas* and *Anthoceros*. Whether the type of thallus found in *Dendroceros* is more primitive than that of *Anthoceros* would be hard to say, as both forms occur among the other primitive Hepatics.

* Leitgeb, Unters. über Lebermoose, Heft 5, p. 27.

EXPLANATION OF THE PLATES.

Plate 21.

Fig. 1. Longitudinal section of the apex of the thallus of *Dendroceros Breutelii* (?). ×600 (about). The limits of the original segments are indicated by the heavy lines.

2. A horizontal section of the apical region of the thallus. The cells *x*, *x'* are probably both initial cells. ♀, the youngest archegonia; *m*, the midrib.

3. A horizontal section, showing a single apical cell.

4. Transverse section of the upper part of a young archegonium, showing four cover-cells.

5. Longitudinal section of a young archegonium, showing the primary divisions. × 600.

6. Longitudinal section of a fully-developed archegonium. *d*, *d*, the cover-cells of the neck. × 600.

7. Longitudinal section of a very young antheridium. Leitz oil-im. $\frac{1}{16}$. Oc. 1.

8. A similar section of an older antheridium.

9. Sections of young antheridia after the segregation of the central tissue × 600. *a*, Longitudinal section; *b*, transverse section.

10. Cross-section of the pedicel of a ripe antheridium, showing four rows of cells. × 600.

11. Longitudinal section of an antheridium, older than those shown in fig. 9. × 350 (about).

12. Sperm-cells from a full-grown antheridium. × 600.

Plate 22.

Fig. 13. Longitudinal section of a fertilized archegonium with young embryo. × 600.

14. An older embryo, showing the archesporium and columella, *col.*; the archesporium is shaded. × 350. II. The first transverse wall in the embryo.

15. Transverse section of a very young embryo. × 600.

16. A similar section of an older embryo.

17. Longitudinal section through the base of an older sporogonium, showing the differentiation of the sporogenous cells (*sp.*) and the elaters (*el.*). × 350.

18. Transverse section near the base of a young sporogonium. × 350. The archesporium is shaded.

19. Upper part of the sporogonium of *D. Breutelii*, with fully-formed spore-tetrads and elaters. × 350. *col.*, columella; *sp.*, spores; *el.*, elaters.

20. A single free elater of *D. Breutelii*. × 350.

x
2
m
3
4
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10
6
d d
a
9
b
7
8
12

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

On the Structure and Development of *Soranthera*, Post. & Rupr.

By Ethel Sara Barton. (Communicated by George Murray, F.R.S., F.L.S.)

[Read 5th May, 1898.]

(Plates **23** & **24**.)

The genus *Soranthera* (Phæophyceæ) was established by Postels and Ruprecht with one species, *S. ulvoidea*, in their 'Illustrationes Algarum,' 1840, p. 19. In the generic diagnosis the structure is said to be that of *Ulva*, while the fructification resembles *Punctaria*. *S. ulvoidea* is described as parasitic on *Rhodomela Larix*, and though the word "parasitic" was probably used in the sense of "epiphytic," investigation proves that the original word was correct, as will be shown. A figure is given of a small group of unilocular sporangia and paraphyses.

The next mention of the plant is made by Endlicher ('Genera Plantarum,' Suppl. iii. 1843, p. 25), where he condenses the original description, but does not omit the word "parasitica." However as he calls *Myriotrichia* also "parasitic," this points to a confusion of terms.

Prof. J. G. Agardh (Spec. Gen. et Ord. Alg. vol. i. p. 120, 1848) quotes the original diagnosis of Postels and Ruprecht, and places the genus as one of doubtful affinity under *Dictyotæ*.

Kützing (Spec. Algarum, 1849, p. 566) follows Prof. Agardh.

In 1850 Ruprecht, one of the joint authors of the genus, in his 'Algæ Ochotenses,' pp. 179, 180, gives a short account of the development of *S. ulvoidea*. Since he speaks of making his investigations with a lens, they are not, as might be expected, exhaustive. At some time an idea had evidently prevailed that *S. ulvoidea* was only a form of *Ulva* (possibly *U. fusca*), and that the sori were a species of *Myrionema*. Ruprecht here shows that this idea must be abandoned, if only on account of the regular distribution of the raised patches of fruit. He recognizes the connection between *Soranthera* and *Asperococcus*, and speaks of the plant, in a wide sense, as *Asperococcus ulvoideus*.

It is interesting to note, in view of the development of *Soranthera*, to be described later, that Ruprecht says it grows mingled with *Leathesia tuberiformis* on *Rhodomela*.

Dr. Kjellman next describes it in a paper "Om Beringhafvets Algflora" (Kongl. Svenska Vetenskaps-Akad. Handl., Bd. xxiii. no. 8, 1889, p. 47). He revives the genus *Soranthera*, but recognizing its resemblance to *Asperococcus*, places it in *Encœliaceæ*. This is the first place in which "epiphytic" is substituted for "parasitic"; and the rhizoids are described as encircling the host plant. A second species was added to the genus by Crouan in Mazé and Schramm's 'Algues de la Guadeloupe,' 1870–1877, p. 131. An authentic specimen of this latter plant is in the Herbarium of the British Museum, and examination proves that it is identical with *Colpomenia sinuosa*, Derb. et Sol. (olim *Asperococcus sinuosus*), frequent in the West Indies. The fruits, which are plentiful on the British Museum specimen, were not described by Crouan. They show the usual plurilocular sporangia of the genus, surrounding a cryptostoma, as described by Miss Mitchell (Phyc. Mem. pt. ii. 1893, p. 53). The genus *Soranthera* is therefore, for the present, reduced to its original species *S. ulvoidea*.

Dr. Kjellman (Engler and Prantl's Natürl. Pflanzenfamil. Teil i. Abteil. 2, 1893, p. 204) and De Toni (Syll. Alg. vol. iii. Fucoideæ, 1895, p. 492) both recognize it under *Encœliaceæ*.

The mature plant of *S. ulvoidea* has the form of a globular sac, which, in the specimens I have seen, does not exceed 2 cm. in diameter (Pl. **23**. fig. 1); but De Toni describes them as subpiriform, and gives their height as 3–4 cm. By searching under a low power among the stichidia of *R. Larix* one finds closely adhering to them minute, semicircular outgrowths, which are the earliest recognizable forms of *S. ulvoidea*. They show no tapering at the base, and look almost like a swelling of the thallus of *Rhodomela* (Pl. **23**. fig. 2). As they grow larger they become more and more detached from the host, till at last, when they reach the size of about 2 mm., the plant is more or less piriform and attached only by its rhizoids.

Even in small plants the size of a pea it is possible to see minute spots, which are young sori, beginning to appear on the surface of the thallus; these grow with the increase of the plant till at last the whole surface is spotted over with the raised patches of fruit.

It has been recorded hitherto from the Behring Straits, and the island of Sitka off the shores of N.W. America. The material on which this investigation has been made was collected at

Monterey, California, by Mr. W. R. Shaw, and sent by him to the British Museum.

In young plants the thallus is composed of filaments which radiate from the base, the cells becoming smaller as they approach the outer surface, where they are free (Pl. **23**. fig. 3). In very early stages these radiating filaments are closely packed together, but as the plant increases in size they become stretched gradually more and more apart and show an anastomosing tissue of cells, through which the original filaments can, however, be clearly traced (Pl. **23**. fig. 4). The outer surface then consists of free 2- or 3-celled assimilative filaments, the upper cell of which is somewhat swollen (Pl. **23**. fig. 7). These assimilative filaments resemble those described and figured by Reinke in *Chordaria* (Algenflora der westlichen Ostsee, p. 75). When the stretching of the internal tissue has reached its limit, the cells become torn asunder, and by the time the plant attains to its full size there remains only a layer of polygonal cells 3–5 deep, which have almost a parenchymatous appearance.

Meanwhile the outer surface has also undergone a change, and instead of the free assimilative filaments the thallus is enclosed by a continuous one-celled peripheral layer, as in *Colpomenia*. Indeed the structure of the mature thallus of these two genera is so similar that it would be interesting to see if the resemblance exists also in young conditions.

For some time it was difficult to trace the connecting links of this unusual alteration in the peripheral layer, and but for the presence in both stages of the typical rhizoids and the cryptostomata characteristic of *Soranthera*, it might have been thought that the two plants were different species. However, at last a specimen was found in which the epidermal layer had evidently been just formed, and in many places single cells were still adhering outside it, showing the remains of the assimilative filaments (Pl. **23**. fig. 5). These had evidently been cast off, and the cells on which they had stood had become pressed together to form a continuous surface. Even after this fact was apparent, a reason for this unusual proceeding seemed far to seek. So far as I know, no member of the *Phæophyceæ* has first a surface of free assimilative filaments and later a compact, continuous epidermis.

As regards the shedding of assimilative filaments, it is known that this takes place in *Elachista scutulata* before the formation

of plurilocular sporangia. The recollection of this led me to examine very closely the sections of *Soranthera* which showed the stage immediately previous to the shedding, to see if in any way this was connected with the formation of fruit. In all the sections I had noticed separate, single-rowed outgrowths consisting of 6 or 7 cells arising from the same cell as the assimilative filaments (Pl. **23**. fig. 6). On comparing these with the plurilocular sporangia of *Chordariaceæ*, notably *Leathesia*, I am led to the belief that they are possibly the plurilocular sporangia of *Soranthera*—although I have of course not seen the escape of the spores, all the material being preserved in spirit. It is hardly strange that empty sporangia have not been seen, since they probably drop off immediately after the escape of the spores.

Another point of resemblance between these supposed plurilocular sporangia of *Soranthera* and those of *Leathesia* is that in both cases they grow all over the thallus and are not confined to sori.

In order to make clear the further development of *S. ulvoidea*, it is necessary to go back to the early stages of the plant and trace the growth of the cryptostomata. Hitherto the only genera in *Encœliaceæ* which have been shown to possess these bodies are *Colpomenia* and *Hydroclathrus* (Miss Mitchell, in Phyc. Mem. pt. ii. 1893, p. 53); but investigation shows that they exist in *S. ulvoidea* from almost the earliest stages of the plant. Even in these, the young hairs of the future cryptostoma can be recognized, growing each from a small oval cell below the surface, similar to the cells which bear the assimilative filaments at the periphery (Pl. **23**. fig. 7). The presence of the smaller cells deep down in the thallus shows that the origin of the cryptostomata is the same as in *Colpomenia* and other algæ, where they are formed from a single initial cell or group, the growth of which is arrested. The young hairs are close together among the surrounding tissue, but their typical basal growth and narrow form enable one to distinguish the position of the future cryptostoma before any sort of hollow has been found. As the plant grows the hairs, growing quicker than the assimilative filaments, push out above the surface, and owing to their length are seldom to be found unbroken in sections of the plant.

In *Colpomenia* and *Hydroclathrus* the cryptostomata are

found in connection with plurilocular sporangia, the only fruit known up to the present for these genera; and Mr. Murray has described a similar connection with the unilocular sporangia in *Adenocystis* (Phyc. Mem. pt. ii. 1893, p. 59).

In *Soranthera ulvoidea* the cells round the cryptostomata begin to divide immediately after the formation of the continuous epidermal layer and to form, centrifugally, sori of large, round-celled paraphyses and unilocular sporangia (Pl. **23**. figs. 8, 9, Pl. **24**. figs. 10, 12). Round those cryptostomata which have few hairs and are not very deep, the sori appear sooner than round those in which the hairs are more numerous. In a mature plant I have found several deep and large cryptostomata (Pl. **24**. fig. 11) round which the cells were at this late stage only just beginning to subdivide to form a sorus. It is remarkable that large well-formed cryptostomata are found in connection with groups of rhizoids on a mature plant. In one case where the cryptostoma, though among the groups of rhizoids, was not actually in close connection with them, the surrounding cells had divided and formed the usual paraphyses as in the sori of unilocular sporangia.

In the older plants the sori, by their centrifugal growth, sometimes coalesce, and thus large patches of fruiting tissue are formed, surrounding two and possibly more cryptostomata.

In the foregoing account of the development of *S. ulvoidea* it has been seen that in the early part of its existence it follows the type of plant found in *Chordariaceæ*, both in vegetative structure and in its plurilocular sporangia. It bears a strong resemblance to *Leathesia*, and in some respects to *Chordaria*; indeed, had *S. ulvoidea* been found only in its young state it would undoubtedly have been placed in *Chordariaceæ*. On the other hand, mature plants, with their continuous epidermal layer and unilocular sporangia surrounding cryptostomata, show so strong a resemblance to genera of *Encœliaceæ*, that it is impossible to doubt the affinity between *Soranthera*, *Asperococcus*, *Colpomenia*, etc.

In Dr. Kjellman's system of classification (Engler and Prantl's Natürl. Pflanzenfam. Teil i. Abt. 2, 1893, pp. 180, 181) a great point is made of the position and mode of development of the sporangia.

In the division including *Chordariaceæ* the sporangia are said

to be formed as the morphological equivalent of an assimilative filament. In the division including *Encœliaceæ* the sporangia arise from the epidermal cells. Both these modes of development are represented in *Soranthera.* Again, the vegetative growth of *Chordariaceæ* is described as terminal or subterminal, that of *Encœliaceæ* as intercalary. Now in *Soranthera* growth evidently takes place in young plants from the ultimate cell of the radiating filaments. This cell bears the assimilative filaments and the plurilocular sporangia, and eventually, after the shedding of these, it forms the epidermal layer which subdivides to keep pace with the further growth of the plant. The presence, too, of cryptostomata points to terminal rather than intercalary growth. The mode of development of *Soranthera,* therefore, comes athwart the lines of demarcation hitherto laid down for the Nat. Orders *Chordariaceæ* and *Encœliaceæ.* It can be placed definitely neither in the one nor the other, and until our knowledge of the life-history of the other genera in these two Orders is more complete it will be wiser to refrain from placing *Soranthera* anywhere.

It is interesting to find in *Soranthera* another instance of a genus, and one of such unsettled position, producing fruits in connection with cryptostomata. That the typical hairs are in so many cases associated with reproductive bodies, either in or out of cryptostomata, points to there being more than a chance connection between them. No satisfactory theory has yet been suggested to explain this, and until the function of these hairs is better understood it is useless to theorize.

Prof. Wille (Beitr. z. Physiol. Anat. der Laminariaceen, Christiania, 1897, p. 36) leans to the hypothesis set forward by Prof. Reinke ("Beitr. z. Kenntniss der Tange," Pringsh. Jahrb. vol. x. p. 317) that these hairs are for the taking up of mineral compounds from the sea-water, a process which would be facilitated by their specially thin outer cell-walls. The contents of the young hairs appear in any case to differ from those of the surrounding tissue; they are richer and in stained sections take a different colour. This has also been noticed by Prof. Wille.

One of the main points of interest in *S. ulvoidea* lies in this, that it adds another to the few known instances of parasitism among the *Phæophyceæ.* Hitherto the only clearly established parasitic species are *Notheia anomala* in *Fucaceæ,* and small algæ

Barton

P. Highley del & lith

Hanhart imp

STRUCTURE OF SORANTHERA.

Highley del. & lith.

STRUCTURE OF SORANTHERA.

belonging to *Elachistaceæ*, *Chordariaceæ*, and *Ectocarpaceæ*. Many of these have been described by M. Sauvageau, "Sur quelques Algues phéosporées parasites" (Journ. de Bot. tom. vi. 1892). In *Soranthera* the cells at the base of the plant in all but the very youngest stage elongate to form septate rhizoids, which intertwine and encircle the thallus of the host, *Rhodomela Larix* (Pl. **24**. fig. 13). The walls of these rhizoids are very thin and stain deeply, but of their contents it is not possible to speak without living material. On reaching the host they become very closely adpressed to it, and after growing round it for a short distance, the ends penetrate into the thallus. Here they push their way through the cells, disorganizing the host tissue and developing small knots of minute cells, which are presumably haustoria (Pl. **24**. fig. 14). It is true that there are certain groups of cells growing from the rhizoids still outside the host plant which strongly resemble the supposed haustoria inside the *Rhodomela* thallus. But this does not necessarily prohibit the possibility of these latter being of the nature of haustoria.

It is probable that the investigation of other plants, hitherto supposed to be merely epiphytic on some one special alga, may lead to the enlargement of the number of parasites among the *Phæophyceæ*.

In conclusion, I wish to express my thanks to Mr. Blackman for kindly helping me in the manipulation of the microtome, while cutting the necessary series of sections; and I gratefully acknowledge the debt I owe to Mr. Murray for placing this and other valuable material in my hands.

EXPLANATION OF THE PLATES.

Plate 23.

Fig. 1. *Soranthera ulvoidea*. Nat. size.
2. Young plants on *Rhodomela Larix*. × 8.
3. Transverse section of young thallus. × 65.
4. Central cells of slightly older plant. × 65.
5. Peripheral layer of still older plant, showing remains of assimilative filaments. × 375.
6. Possible plurilocular sporangia. × 375.
7. Young cryptostoma. × 375.
8. Cells round older cryptostoma, dividing to form sorus of paraphyses and unilocular sporangia. × 375.
9. Mature sorus of unilocular sporangia. × 140.

PLATE **24**.

Fig. 10. Part of mature sorus of unilocular sporangia. × 375.
11. Large cryptostoma. × 375.
12. Sorus round large cryptostoma. × 140.
13. Rhizoids penetrating into host plant. × 140.
14. Part of same. × 375.

A Revision of the Genus *Symblepharis*, Montagne. By ERNEST STANLEY SALMON. (Communicated by E. M. HOLMES, F.L.S.)

[Read 2nd June, 1898.]

(PLATES **25** & **26**.)

THE genus *Symblepharis* was established by Montagne in Ann. Sci. Nat. sér. II. viii. p. 252 (1837), for the reception of a Mexican moss, which he named *S. helicophylla*.

In this species the sixteen teeth of the peristome are more or less completely united below in pairs, and so form eight groups. Each group, or pair of teeth, is separated from the next, as Montagne remarked, by an interval about equal to the width of a simple tooth (Pl. **25**. fig. 2).

The teeth of *S. helicophylla*, when wet, are strongly connivent into a cone (fig. 1).

These two peristome characters were considered of generic value by Montagne, and from the first—the distinct arrangement of the teeth in pairs—the genus derives its name.

Mitten, in his work on Indian mosses (**1**), sank *Symblepharis* in *Leptotrichum*, Hampe; and in his remarks on *Leptotrichum Reinwardti*, Mitt. (*Gyrophyllum Reinwardti*, Dozy & Molkenb.), said: "Habitus omnino præcedentis [*L. himalayanum*, Mitt.], quocum structura adeo convenit ut nulla methodo naturali separari potest. Peristomium dentibus æqui-distantibus dicranis ab eo *L. himalayani* et specierum aliarum *Symblephari* generi adscriptarum diversum, sed differentia hæcce momenti ejusdem ut in speciebus *Orthotrichi* generis censenda est."

But although the acceptance of the genus *Symblepharis* as defined by Montagne would lead, as Mitten pointed out, to the separation of species closely allied, we find that, if we do away

with Montagne's special peristome characters, so as to admit species (like *S. Reinwardti*, Mitt., Pl. **26**. fig. 34) with a peristome of sixteen equidistant recurved teeth, there are vegetative characters left of sufficient value for keeping up the genus.

This appears to have been the later opinion of Mitten, as in his work on the South-American mosses (**2**), he revived the genus *Symblepharis*, but without including the original peristome characters, and it is this emended generic description of Mitten's that must be accepted.

We have, then, a genus of a few species of arboreal mosses of a distinct habit, which closely resemble one another in the shape and areolation of the leaves, strongly crisped when dry, differing in these points from *Leptotrichum*, *Dicranella*, and *Angstrœmia*, and from *Holomitrium* in the absence of distinct alar cells.

S. HELICOPHYLLA, *Mont. in Ann. Sci. Nat.* sér. II. viii. p. 253 (1837).

Montagne (*loc. cit.*) gives a full and excellent description of his species. The leaves are described as "apicem versus margine dentata," but, although this is the case with most leaves, exceptions may often be found. In the authentic specimens (*ex herb.* Montagne) at Kew, for instance, some leaves have a quite entire margin.

In C. Müller, Syn. i. p. 461, the characters "nervo . . . excurrente, apice dorso scabro" are added to Montagne's specific description. This roughness of the nerve is very variable, and seems to be correlated with the amount of serration of the margin; as the margin tends to become less serrate the roughness of the nerve is reduced to a few scattered points, until with an entire margin a quite smooth nerve is found. I do not find the nerve excurrent, but ceasing in the apex.

In 1828 Hooker published, in Wall. Cat. no. 7571, the name (without description) of *Didymodon vaginatum* for a moss collected by Wallich in Nepal; in 1837 the same author (**4**) figured the moss, and in 1840 (**5**) published the specific description.

In 1857 Wilson (**6**) gave the MS. name *Symblepharis Hookeri* to Hooker's *Didymodon vaginatum*, and separated a form with "leaves longer, wider at base, less crisped when dry," as *Symblepharis dilatata*, Wils. MS.

In 1859 Mitten (**1**) placed both these in *Leptotrichum* under the name of *L. himalayanum*, Mitt., but in 1888 (**3**) referred to this moss as a true *Symblepharis*, and there are specimens in the Kew Herbarium named by him, in 1891, *Symblepharis himalayanum*, Mitt. There is a fine series of this Indian moss in the Kew Herbarium, and an examination of this has led me to the conclusion that there is nothing to separate the specimens from *S. helicophylla*, Mont.

Hooker's original figure and description of *Didymodon vaginatum* are not full enough to be of much value, but as far as they go contain nothing unfavourable to the view of the identity of the two. At first sight the Indian specimens seem to differ in having, often, a shorter capsule, seta usually solitary, and almost or quite entire leaves with the nerve frequently quite smooth at back. But in many cases the capsules of the Indian specimens are longly cylindrical, and, on the other hand, some Mexican examples of *S. helicophylla* have a somewhat elliptical capsule.

The number of setæ arising from a perichætium varies from one to three—rarely four or five—in Mexican *S. helicophylla*; in the Indian moss it is usually one, but sometimes two. I do not think this difference important, especially as in the American *S. Oerstediana*, C. Müll., which, as mentioned below, Mitten considers a form of *S. helicophylla*, the seta is solitary, just as is usually the case in the Indian specimens. As regards the leaves, although those of the Indian plants differ, generally, in the points noted above, there are many exceptions. In the specimen at Kew labelled "*Leptotrichum himalayanum*, Mitt., no. 112, Herb. Ind. Or. Hook. fil. & Thomson, Coll. J. D. Hooker," the leaves agree in the serrate margin and nerve prominently rough at back with those of typical *S. helicophylla*; and between such leaves as these and the smaller entire ones of many of the Indian specimens a complete series of intermediates can be found. In the peristome, areolation, inflorescence, &c., I can find no constant difference separating the Indian plant from the Mexican.

It is interesting, with regard to the question of the identity of these two mosses, to find among Schimper's MSS. preserved at Kew some notes on a moss which commence, "*Didymodon vaginatum*, Hook., Journ. of Bot. vol. ii., et Hook. Icon. Plant.

tab. xviii.—*Symblepharis helicophylla*, Montagne. Mexico, Liebman"; and there are specimens of *S. helicophylla* from Mexico in Schimper's herbarium named "*D. vaginatus*, Hook."

S. Oerstediana, C. Müll. Syn. ii. p. 613 (1861), as pointed out by Mitten (2. p. 49), must be referred to *S. helicophylla*, and is not dioicous as described. The specimens in the Kew Herbarium (coll. Oersted) I find are autoicous, just as in *S. helicophylla*.

S. Chrismari, S. Müll. Syn. ii. p. 614 (1851).

The description of this moss commences "*S. helicophyllæ* simillima, sed folia angustiora breviora e cellulis *mollibus chlorophyllosis, nunquam incrassatis, areolata*; thecæ angustissime cylindricæ elongatæ erectæ *valde falcato-arcuatæ*." The other characters given do not differ from those of *S. helicophylla*.

Through the kindness of Prof. C. Müller I have been able to examine a specimen of this plant (now in the Kew Herbarium). I certainly do not think it is distinct from *S. helicophylla*. First, as to the cells: these are decidedly incrassate (Pl. 26. figs. 27, 28), in some leaves less so than in others, but agreeing essentially with those of *S. helicophylla*, where, in the Indian examples especially, the amount of incrassation is slightly variable. The character of the different shape of the capsule is not shown by the specimen sent by Prof. Müller. There are two capsules on this: one longly cylindrical and curved, 3 mm. long; the other elliptical and straight, 1·50 mm. long. This shows how invariable the shape and size of the capsule are in *Symblepharis*, and the little value of characters depending on these. Leaves quite as narrow and short often occur in *S. helicophylla*.

In 1891 Bescherelle (7) published a species of *Symblepharis*, *S. asiatica*, from Yun-nan, China, with the following description:—"Offre le port du *S. helicophylla* Mont. du Mexique; ses feuilles à peine denticulées au sommet, à nervure lisse, ses pédicelles solitaires, sa capsule cylindrique courbée l'en distinguent suffisamment."

The specimens of this (ex herb. Bescherelle) in the Kew Herbarium do not agree well with this description, especially in those points in which the author contrasts the species with *S. helicophylla*. The nerve of most of the leaves is rough at back above, often quite prominently so; also among the few

plants of the Kew specimen there is one showing two setæ coming from the same perichætium. In the leaf, capsule, and peristome there is no difference, and there seem, therefore, no characters to separate *S. asiatica* from *S. helicophylla.* In 1892 Bescherelle (**8**) gave a fuller description of his species, but only the same characters, quoted above, are given as separating it from *S. helicophylla.*

S. breviseta, Lindb. MS. in herb. (non Wils.), is nothing but a form of *S. helicophylla* with very short setæ. Exactly similar states may be found mixed with normal plants of *S. helicophylla* in the same tuft, as may be seen in the Desierto Viejo specimens (M. Bourgeau) in the Kew Herbarium.

S. HELICOPHYLLA, var. MICROTHECA.

There is a moss in the Kew Herbarium, from Tihri-Garhwal, N.W. Himalaya (J. F. Duthie, 1893), named *S. microtheca*, C. Müll., but I cannot find any published description of this name. The specimen is identical with some small forms of "*Leptotrichum himalayanum*, Mitt.," in the Kew Herbarium, and differs from typical *S. helicophylla* only in the smaller size, leaves with almost or quite entire margin, and nerve faintly rough, or smooth at back, elliptic-oblong capsule on a shorter seta, and little branched stems (Pl. **25**. figs. 17–23). Such plants are somewhat intermediate between *S. helicophylla* and the var. *tenuis* described below, and it would be convenient to retain *microtheca* as a varietal name for these Indian forms, although there are certainly intermediates connecting them with the type.

S. HELICOPHYLLA, var. TENUIS.

S. tenuis, Schimp. MS. in Herb.

S. caulibus erectis brevibus (2–6 mm.) simplicibus; foliis minoribus 3–4 mm. longis, marginibus integerrimis vel apice minute serrulatis, nervo lævi vel dorso ad apicem minute scabro, thecis in pedunculo longo (1 cm.) erectis parvulis ellipticis oblongisve, sporis minoribus.

This is a well-marked variety. The very short unbranched stems, slender setæ (often over a centimetre long), short leaves, and small capsules give it a very distinct appearance (Pl. **25**. figs. 3–16). The spores are about 12 μ in diam., and are slightly

smaller than in the type. The leaves are entire, or nearly so, with the nerve smooth, or faintly rough at back above. Except in the smaller size, the peristome, shape of the leaf, &c. do not differ from those of *S. helicophylla*.

Besides the plant named *S. tenuis*, from Simla, in Schimper's Herbarium, there are specimens in the Kew Herbarium from two other localities which belong here: one named *S. himalayanum*, Mitt., from Mahasso; the other, named *S. Hookeri*, Wils., from between Konrin and Mandali (J. F. Duthie, 1895). Schimper's plant is slightly smaller than these, but is certainly identical with them. Duthie's specimens are very fine and vigorous, and may be considered typical of the var. *tenuis*.

S. pusilla, Hampe, MS. in Herb., resembles *tenuis* in its small size, but differs in the shape of the capsule, which, though variable, is usually somewhat cylindrical, the shorter setæ, and more vigorous stems. This I am inclined to consider a stunted and abnormal form of the type, rather than belonging to the var. *tenuis*.

S. HELICOPHYLLA, var. MACROSPORA.

S. Hookeri, var. capsula elliptica, operc. oblique rostrato, *Wils. in Kew Journ. Bot.* ix. p. 292 (1857).

S. Kurzii, Hampe, MS. in Herb.

Thecis late ellipticis, operculo longiore, sporis magnis (35–45 μ) asperulis.

The short and broadly elliptic capsules and very large spores easily separate this variety from all forms of *S. helicophylla*. The spores of *S. helicophylla* are from 15–20 μ, and smooth, or nearly so; those of *macrospora* are more than twice their size, and rough with scattered warts. In other respects the variety does not differ from the Indian examples of *S. helicophylla*, except that the interval between each pair of teeth of the peristome is very slight or does not exist.

The plant in the Kew Herbarium, to which Wilson's remarks apply, is very striking in the broad, elliptic capsule (1 mm. wide, 2 mm. long), and spores averaging 40 μ (Pl. **26**. figs. 24–26). *S. Kurzii*, Hampe, MS. in Herb., also belongs here. Hampe's specimens have the note:—"Thecis ellipticis, dent. perist. integris, operculo longiore differt." The peristome teeth are not entire, but bifid exactly as in *S. helicophylla*. The capsules are

not quite so broadly elliptic as in the Kew example; the spores average 35 μ.

In the large series at Kew I could find no spores intermediate in size between *helicophylla* and this variety, and it seemed as though the latter might deserve specific rank; but in Hampe's Herbarium, at the British Museum (Natural History), there is a moss named "*S. Hookeri*, Wils., *minor*. Sikkim, 11,000 ft. (S. Kurz), no. 2331," which is exactly intermediate between *S. helicophylla* and the variety *macrospora*, both in the shape of the capsule and size of spores, which are from 20–30 μ in diameter. The occurrence of this connecting link is very interesting, showing, as it does, that even in the size of the spores *S. helicophylla* is a variable species. Such intermediates are certainly rare, and their occurrence does not, I think, lessen the claim of *macrospora* to rank as a well-marked variety.

If the foregoing conclusions be accepted, we must look upon *S. helicophylla*, Mont., as a variable species, giving rise to several well-marked varieties, and must allow it a wider distribution than has been previously accorded to it. The species will stand as follows:—

S. HELICOPHYLLA, *Mont. in Ann. Sci. Nat.* sér. II. viii. p. 253 (1837); *C. Müll. Syn.* i. p. 461 (1849); *Mitt. Musc. Austr. Amer.* p. 48, *in Journ. Linn. Soc., Bot.* xii. (1869); *Jaegr. Adumbr.* i. p. 73 (1872).

Didymodon vaginatum, Hook., in Wall. Cat. no. 7571 (1828); Hook. Ic. Plant. t. xviii. fig. 4 (1837); Lond. Journ. Bot. ii. p. 5 (1840); C. Müll. Syn. i. p. 462 (1849).

Symblepharis Oerstediana, C. Müll. Syn. ii. p. 613 (1851); Mitt. Musc. Austr. Amer. p. 48 (1869); Jaegr. Adumbr. i. p. 73 (1872).

S. Chrismari, C. Müll. Syn. ii. p. 614 (1851); Mitt. Musc. Austr. Amer. p. 49 (1869); Jaegr. Adumbr. i. p. 73 (1872).

S. Hookeri et *S. dilatata*, ex parte, Wils. in Kew Journ. Bot. ix. pp. 292, 293 (1857).

Leptotrichum himalayanum, Mitt. Musc. Ind. Orient. p. 12 (1859).

Dicranella himalayana, Jaegr. Adumbr. i. p. 82 (1872).

Symblepharis Hookeri, Wils., Jaegr. Adumbr. ii. p. 636 (1879).

S. asiatica, Besch. Rev. Bryol. 1891, p. 88, in Ann. Sci. Nat. sér. VII. t. 15, p. 50 (1892).

Dichodontium Hookeri, Par. Index Bryol., in Act. Soc. Linn. Bord. xlvi. p. 332 (1893).

Distribution :

N. America—Mexico : Oaxaca (D. Andrieux); Cerro de los Nebejos (C. Ehrenberg); Forêt del Desierto Viejo, vallée de Mexico (M. Bourgeau, 1865), under *S. helicophylla*; Orizaba, 12,000 ft. (Liebmann), under *Didymodon vaginatus*, Hook.; Prov. Mechoacan, Cerro San Andres, and Jalapa (Chrismar, 1849), under *S. Chrismari*.

Central America—Costa Rica : 5000–8000 ft. (A. S. Oersted, 1848); V. Irazu, near Cartago, 9000–11,000 ft. (Wendland, 1857), under *S. Oerstediana*.

Asia—India, Himalaya : Bhotan, Sanah, 8000–10,000 ft.; Punjaub, Mahasso; British Garhwal, 8000–10,000 ft. (J. F. Duthie, 1885); Nepal (Wallich) (J. D. Hooker); Sikkim, 7000–12,000 ft. (J. D. Hooker), 8000–13,000 ft. (S. Kurz); Kumaon, 6000–9000 ft. (Strachey, Winterbottom, T. Thomson), under *Leptotrichum himalayanum*, Mitt.; *Symblepharis himalayana*, Mitt.; *S. Hookeri*, Wils.; *S. vaginata*, Hook.; and *Didymodon vaginatum*, Hook. *China* : Yun-nan; bois de Tong-chan et de San-tchang-kiou (Hokin), 2500 mtr. (Delavay, 1890, no. 4875), under *S. asiatica*.

Var. microtheca.

S. microtheca, C. Müll.

Distribution.—*Asia, India, Himalaya*: near Deota, Tihri-Garhwal, 9000–10,000 ft. (J. F. Duthie, 1893); Mahasso (Herb. Griffith, no. 97); Chola, Sikkim, 10,000–12,000 ft. (J. D. Hooker, no. 125 *b*, bottom specimen only).

Var. tenuis.

S. tenuis, Schimp. MS. in Herb.

Distribution.—*Asia, India, Himalaya* : Simla, Delhi (Lady H. M. Lyell, 1853); Mahasso (Herb. Griffith, no. 19); between Konrin and Mandali, 7000–9000 ft. (J. F. Duthie, 1895, no. 17943).

Var. macrospora.

S. Hookeri, var. capsula elliptica, operc. oblique rostrato, *Wils. in Kew Journ. Bot.* ix. p. 292 (1857).

S. Kurzii, Hampe, MS. in Herb.

Distribution.—*Asia, India, Himalaya*: Tonglo, Sikkim,

7000–8000 ft. (J. D. Hooker, no. 110); Sinchul, Sikkim, 7500–8000 ft. (S. Kurz, nos. 2090, 2390).

SYMBLEPHARIS LINDIGII, *Hampe, in Linnæa*, xxxii. p. 136 (1863); *et Ann. Sci. Nat.* sér. V. t. iii. p. 359 (1865); *Mitt. Musc. Austr. Amer.* p. 48 (1869); *Jaegr. Adumbr.* i. p. 73 (1872).

S. boliviana, C. Müll. Prod. Bryol. Boliv., in Nuov. Giorn. Bot. Ital. p. 39 (1897).

DISTRIBUTION:

South America—New Granada: Paramo Choaché, 3600 mtr. (A. Lindig, 1860, no. 2130).

Bolivia: prov. Larecaja, Sorata, 3400 mtr. (G. Mandon, 1858, no. 1656); prov. Cochebamba, near Choquecamata (Germain, 1889).

Ecuador: Andes of Quito, Pallatenga, 6000 ft. (Spruce, no. 26 *b*).

Spruce's Pallatenga plant, of which there are specimens in the Kew Herbarium correctly named *S. Lindigii*, is, by a slip, referred to as belonging to *S. helicophylla*, Mont., by Mitten (**2**), and consequently the latter species is wrongly recorded from this locality.

The leaves of *S. Lindigii* are quite entire, and more or less transversely undulate above when wet; the nerve is smooth at back. The spores are rough with minute warts, just as in *S. helicophylla*, var. *macrospora*.

The Bolivian plant has lately been separated as a distinct species by Müller (**9**) under the name of *S. boliviana*.

Hampe's original description of *S. Lindigii* differs from that of *S. boliviana* in the following points:—seta erecta, theca cylindrica, peristomii dentibus integris vel parum fissis.

Müller (**9**) remarks on his plant, "Fructibus ditissimis minute oblongis in pedicello Campylopodis instar humore curvato dispositis prima fronte ab omnibus congeneribus distincta."

There are Bolivian specimens collected by Mandon (no. 1656) in the Kew Herbarium (quoted by Müller as *S. boliviana*). The setæ of these become curved when wet, as Müller says, though in these examples not to such a degree as to suggest a *Campylopus*.

But in Hampe's type of *S. Lindigii*, at the British Museum (Natural History), the setæ when wetted become slowly curved,

so that it is evident Hampe's description, "seta erecta," applied to the dry state only.

The capsules of the type specimens of *S. Lindigii* are certainly more cylindrical than in the Bolivian ones, but a few capsules occur which are oblong. The teeth of *S. Lindigii* are very fragile, and are so strongly incurved when wet, that it is difficult to see how much the apex of each tooth is divided. The peristomes are mostly imperfect in the ripe capsules of the type of *S. Lindigii*, but some show teeth bifid to the middle. Müller (9) describes his peristome teeth as "usque ad medium fissi," but I have noticed several teeth quite entire in Mandon's specimen, no. 1656, from which fig. 33 was drawn.

In *S. helicophylla*, Mont., the peristome teeth are very variable in this respect; entire and bifid teeth commonly occur in the same peristome (Pl. **25**. fig. 7).

S. fragilis, *Mitt. Musc. Austr. Amer. in Journ. Linn. Soc.* xii. (1869) p. 49; *Jaegr. Adumbr.* i. p. 74 (1897).

Distribution.—*S. America*: Ecuador, Andes of Quito, near Mulmul and Tunguragua, 9000 ft. (Spruce, no. 23, and Jameson).

S. fragilis, Mitt., differs in its rigid habit from all other species of the genus. In Mitten's description there is no mention made of the structure of the leaves, which is quite different from that of the other species. The leaves are very fragile, *i.e.* brittle through their rigidity, so that they are usually broken across above, and are bistratose in the upper part (Pl. **26**. fig. 30). The transition from the unistratose structure of the lower part (Pl. **26**. fig. 29) to this takes place just above the wings of the vaginant base. The two "stereïd-bands," which take a prominent part in the nerve-structure of the leaf-base, gradually disappear as the apex is reached. The leaf-cells are quadrate to shortly rectangular, not "rotundatus" as described. The peristome teeth (not described by Mitten) are more or less bifid, sometimes to the middle, and often irregularly perforated, and are not arranged in pairs. The inflorescence is autoicous.

S. socotrana, *Mitt., in Balf. f. Bot. Socotra, in Trans. Roy. Soc. Edinb.* xxxi. p. 331 (1888).

Distribution.—*Africa*: Socotra, on highest points of Haghier (Prof. Bayley Balfour, 1880).

The leaves in shape and areolation seem to refer this moss to the genus *Symblepharis*, but as only very old capsules, with no trace of peristome, have been found, its true position, as Mitten 3. p. 330) says, must remain at present doubtful. I find that the cells of the upper part of the leaf, which are quadrate, not "rotundatus" as described, are papillose on both sides, with the exception of the back of the nerve (Pl. **26**. fig. 32). The elongated rectangular cells of the base are smooth (fig. 31). The nerve is more robust in the subula than lower down.

Should this moss prove to be a *Symblepharis*, it will differ from all present described species in the papillose cells.

S. Reinwardti, *Mitt., in Balf. f Bot. Socotra, in Trans. Roy. Soc. Edinb.* xxxi. p. 331 (1888).

Dicranum Reinwardti, Dozy & Molkenb. Musc. Frond. Archip. Ind. p. 6 (1844).

Gyrophyllum Reinwardti, Dozy & Molkenb. Musc. Frond. Ined. Archip. Ind. p. 149, t. 45, 46 (1846).

Angstrœmia Reinwardti, C. Müll. Syn. i. p. 437 (1849).

Symblepharis dilatata, ex parte, et *S. breviseta*, Wils. in Kew Journ. Bot. ix. p. 293 (1857).

Leptotrichum Reinwardti, Mitt. Musc. Ind. Orient. p. 12 (1859).

Dichodontium Reinwardti, Dozy & Molkenb. Bryol. Javanic. i. p. 85 (1859); Jaegr. Adumbr. i. p. 67 (1872); Par. Index Bryol., in Act. Soc. Linn. Bord. xlvi. p. 334 (1893).

Distribution.—*Asia*: Java; Borneo (Korthals); India, Sikkim Himalaya, 10,000–11,000 ft. (J. D. Hooker); Lower Burma, Moulmein (Rev. C. Parish).

As pointed out by Mitten (1), the habit of this species is entirely that of the Indian "*Leptotrichum himalayanum*," and it is interesting to find in the leaves of the present species just the same kind of variation.

The leaves of *S. Reinwardti*, Mitt., are described as serrulate above, with a nerve rough at back above. Frequently, however, the margin is subentire, and the nerve shows only one or two minute protuberances, and occasionally a quite entire margin and smooth nerve is found.

In many instances the shape of the leaf is identical in the two species, but I believe barren plants can be separated safely by observing the following characters.

The leaf-base of *S. helicophylla* is formed of wider, quad-

rangular cells, with narrow walls not constricted; in *S. Reinwardti* the cells are narrower, with thicker walls, which are more or less strongly constricted at intervals. A difference is very noticeable, too, where the vaginant base passes into the subula. In *S. helicophylla* the elongated rectangular cells pass quickly into the more or less quadrate incrassated cells of the upper part; in *S. Reinwardti* the transition is more gradual, and the space is occupied by irregularly shaped cells, with the cell-walls strongly constricted at intervals (*cf.* figs. 12, 13, & 35, 36). The areolation of the upper part of the leaf of *S. Reinwardti* shows considerable variation: the cells are sometimes regularly quadrate, usually elongate-quadrate, but sometimes more or less wavy in outline, and the cell-walls constricted at intervals like those of the lower cells.

The Java and Borneo specimens have a rather different facies from the Indian ones, due to the larger, more crowded, and softer leaves of a warm yellowish colour; the Indian ones have shorter, more rigid leaves, duller and paler in colour.

It is interesting to find the Moulmein specimens just intermediate in these characters.

Excluded Species.

S. ? circinata, Besch., in Ann. Sci. Nat. sér. VI. ix. p. 308 (1878 [1879]).

DISTRIBUTION.—*Africa*: La Réunion; plaine des Cafres (G. de l'Isle; Lépervanche, 1876); Grande Comore (Boivin).

There are specimens of this (ex herb. Bescherelle) from both localities in the Kew Herbarium, and I find that there are two distinct mosses represented.

Bescherelle's description applies best to the Grande Comore plant; the La Réunion one has shorter, much broader, somewhat lingulate leaves, rather suddenly narrowed to a triangular point, nerve only slightly excurrent, different base, &c. The following remarks refer to the Grande Comore plant. Bescherelle (*loc. cit.*) concludes his description with the observation, "Espèce inconnue en fructification, et qui paraît très voisine du *S. Chrismari* du Mexique."

The specimens I have examined, however, bear no resemblance

in any way to *S. Chrismari*, which, as remarked above, I consider only a form of *S. helicophylla*.

I do not think the present species is a *Symblepharis*; the areolation and shape of the leaf are quite unlike anything found in the genus, and also the leaf-base shows an important difference. Bescherelle describes this as "e cellulis hyalinis rectangulis areolata," but I find a rather different structure. The cells towards the nerve are relatively large, rather firm-walled, rectangular, and empty, but at the margin are narrow, short, and very thin-walled, forming a more or less evident border (Pl. 26. fig. 37). These two kinds of cells are very clearly seen in a transverse section of the leaf-base (fig. 38). This structure is just what occurs in *Syrrepodon circinatus*, Schpr. non Mitt. (Besch. Prod. Flor. Mex., Mém. Soc. Sci. Nat. Cherb. xvi. p. 172 (1872)); and I would point out the close agreement in habit, shape of leaf, and areolation of this species with the Grande Comore moss.

S. usambarica, Broth., in Engl. Bot. Jahrb. xx. p. 179 (1895).

Distribution.—*Africa*: Usambara (Holst, 1891, no. 115 p.p.).

Through the kindness of Dr. V. F. Brotherus, I have received a specimen of this moss, now in the Kew Herbarium.

It certainly does not, in my opinion, belong to the genus *Symblepharis*. The leaves are comparatively short and broadly lanceolate, with opaque, very papillose cells; the fruit has not been found. Brotherus remarks on his plant, "A *S. circinata* Besch. proxima foliis brevioribus, parte basilari late vaginante superne dilatata, facile dignoscitur." Bescherelle's *S. circinata* from Grande Comore and La Réunion includes, as mentioned above, two distinct mosses, and the specific description applies best to the specimens from the former locality. *S. usambarica*, however, very closely resembles the La Réunion plant, from which it scarcely differs except in the broader, more vaginant base, so that it appears that Brotherus has accepted this as Bescherelle's *S. circinata*.

S. perichætialis, Wils., Hook. f. Fl. New Zeal. ii. p. 60 (1855); Hook. f. Handb. New Zeal. Fl. p. 405 (1867) = *Holomitrium perichætialis*, Brid.

S. densifolia, Wils., in Kew Journ. Bot. ix. p. 292 (1857) = *Holomitrium Griffithianum*, Mitt.

S. pumila, Hook. f., Handb. New Zeal. Fl. p. 405 (1867)= *Holomitrium pumilum*, Mitt. MS.

Species not seen.

S. jamaicensis, C. Müll., in Bull. l'Herb. Boiss. t. v. (1897) p. 555.

S. Hildebrandii, C. Müll. l. c. p. 850 (1897).

S. sinensis, C. Müll., in Nuov. Giorn. Bot. Ital. v. p. 171 (1898).

Bibliography.

(1) Mitten, "Musc. Ind. Orient." Journ. Linn. Soc. (Bot.) iii. Supp. pp. 1–158 (1859).

(2) Idem, "Musc. Austr. Amer." Journ. Linn. Soc. (Bot.) xii. pp. 1–632 (1869).

(3) Idem, Balfour's Botany of Socotra. Trans. Roy. Soc. Edinb. xxxi. p. 331 (1888).

(4) Hooker, Ic. Pl. i. xviii. t. 4 (1837).

(5) Idem, Lond. Journ. Bot. ii. p. 5 (1840).

(6) Wilson, Kew Journ. Bot. ix. p. 292 (1857).

(7) Bescherelle, Rev. Bryol. 1891, p. 88.

(8) Idem, Ann. Sci. Nat. sér. VII. t. 15, p. 50 (1892).

(9) Müller, "Prod. Bryol. Boliv." Nuov. Giorn. Bot. Ital. p. 39 (1897).

[Since the above was written, Mr. C. H. Wright has kindly shown me a moss named *Symblepharis obliqua*, Broth., just received at Kew among some British New Guinea mosses determined by Brotherus. The description of this moss has not yet appeared.

The leaves show well-defined alar cells, and the plant, in my opinion, belongs to *Holomitrium*, with which genus it agrees well in habit, &c. It is probably the form of the peristome that has led to the moss being placed in *Symblepharis*. The peristome is composed of teeth approximated in pairs, and somewhat closely resembles that of *S. helicophylla*, Mont. But just as *Symblepharis*, as mentioned above, must be widened to include mosses with equidistant teeth, so must *Holomitrium* be allowed to include species with the teeth arranged in pairs. This has, in

fact, already been done, by including *Holomitrium perichætiale*, Brid., in the genus, for the peristome here is similar in arrangement to that of the New Guinea moss. *H. perichætiale* is evidently in other respects closely related to Brotherus's plant.

To the list of Excluded Species, given above, should now, therefore, be added *S. obliqua*, Broth. MS. in Herb. Kew=*Holomitrium obliquum*, Salmon. E. S. S.]

7th June, 1898.

EXPLANATION OF THE PLATES.

Plate 25.

Fig. 1. *S. helicophylla*, Mont.; mouth of capsule, with wet connivent peristome. × 52.
2. Four teeth of same, united in pairs. × 150.
3. *S. helicophylla*, Mont., var. *tenuis*. Nat. size.
4. Ditto; capsule. × 25, reduced to half size.
5, 6. " wet connivent peristome. × 52.
7. " portion of peristome. × 150.
8. " spores. × 255.
9. " leaf. × 25.
10, 11. " apex of two leaves. × 150.
12, 13, 14. " areolation of leaf at *a*, *b*, & *c*. × 255.
15. " trans. sect. of leaf-base. × 400.
16. " " upper part of leaf. × 400.
17. *S. helicophylla*, Mont., var. *microtheca*; capsule. × 25, reduced to half size.
18. Ditto; mouth of capsule. × 52.
19. " two teeth of peristome. × 150.
20. " spores. × 255.
21. " leaf. × 25.
22, 23. " apex of two leaves. × 150.

Plate 26.

Fig. 24. *S. helicophylla*, Mont., var. *macrospora*; capsule. × 25, reduced to half size.
25, 26. Ditto; spores. × 255.
27, 28. *S. Chrismari*, C. Müll.; areolation of upper part of leaf. × 255.
29. *S. fragilis*, Mitt.; trans. sect. of leaf-base. × 400.
30. Ditto; trans. sect. of upper part of leaf. × 400.
31. *S. socotrana*, Mitt.; trans. sect. of leaf-base. × 400.
32. Ditto; trans. sect. of upper part of leaf. × 400.
33. *S. Lindigii*, Hampe; portion of peristome. × 150.

E.S.S. del. A.R.Hammond lith.

Hanhart imp

STRUCTURE OF SYMBLEPHARIS.

E.S.S. del A.R.Hammond lith

Hanhart imp

STRUCTURE OF SYMBLEPHARIS.

PLATE 26 (*continued*).

Fig. 34. *Symblepharis Reinwardti*, Mitt.; mouth of capsule. × 25.
35. Ditto; areolation of leaf-base. × 255.
36. „ „ between leaf-base and subula. × 255.
37. *S. circinata*, Besch.; part of leaf-base. × 255.
38. Ditto; trans. sect. of leaf-base. × 400.

Preliminary Observations on the Seasonal Variations of Elevation in a Branch of a Horse-Chestnut Tree. By MILLER CHRISTY, F.L.S.

[Read 16th June, 1898.]

(PLATE 27.)

GROWING in my garden at 'Pryors,' in the parish of Broomfield, about two miles north-east from Chelmsford, is a tree of the Horse-Chestnut (*Æsculus Hippocastanum*).

Five or six years ago my attention was attracted to it by observing the fact that the elevation above the ground of a certain branch of this tree which happened to project over one of the garden paths varied very noticeably at different seasons of the year. During mid-winter, when the branch was bare of leaves, its elevation above the ground was so great that no obstruction was caused to the path beneath; but, at mid-summer, when the branch was covered with leaves, its elevation above the ground was so slight as to interfere very inconveniently with free passage along the path.

Having noticed this fact for a year or two, it occurred to me that, if I made a series of observations in order to determine precisely what was the amount of this seasonal variation, the result might prove of some interest. I have now continued these observations for exactly three years, and I propose, in what follows, to detail the result.

The fact that branches of trees do undergo certain seasonal changes in elevation above the ground will, of course, have been observed by every one in the case of cultivated fruit-trees, the

branches of which are often greatly bent downwards, and sometimes broken, by the weight of the fruit they bear. This, however, is not quite the same thing as that herein discussed. In the first place, in the case of these fruit-trees, the conditions are somewhat abnormal; for the weight of the fruit they bear is generally very much greater, in proportion to the strength of the branches, than that ordinarily borne by trees growing in a state of nature. In the second place, the conditions, beside being somewhat abnormal, are also in another way essentially different; for, in the case of these fruit-trees, the effect in question is mainly produced by the weight of the *fruit* and not (as in the case under consideration) mainly by the weight of the *leaves*.

The Horse-Chestnut tree producing the branch upon which my observations have been made is a small one, about 40 feet in total height, growing in a position where it is a good deal shaded and overcrowded by other, and larger, trees. The branch in question is the lowermost upon the tree. It leaves the bole about four feet above the ground, where the bole is about 53 inches in circumference. The branch, at the point where it leaves the bole, is about 26 inches in circumference, and it is about 28 feet 6 inches in total length, excluding the leaves.

In order to render easy the carrying on of my observations, I drove a large nail into the side of the branch at a point 16 feet 3 inches from the bole (and, consequently, 12 feet 3 inches from the extremity); while, immediately beneath the nail, I buried a brick so that one end of it just appeared above the surface of the ground. It was then an easy matter to measure with a piece of cord the periodical variations in the distance between the nail and the top of the brick.

My observations were continued at short intervals from April 21st, 1895, till April 23rd, 1898—a period (as already stated) of exactly three years. During this period I measured the distance between the nail and the brick no fewer than 42 times (12 times in 1895; 9 times in 1896; 14 times in 1897; and 7 times in 1898)—that is, on an average, about once a month. The results are stated in detail in Table A, which appears on the following page and requires no explanation.

Table A.

No. of Observation.	Date of Observation.	Elevation.	Ascent or Descent.	Remarks on the Observation.
	1895.	in.	in.	
1.	April 21.	81	—— ?	Leaves just coming out.
2.	,, 28.	79½	↘ 1½	Leaves fast coming out.
3.	May 19.	75	↘ 4½	Leaves and flowers fully out.
4.	June 6.	74½	↘ ½	
5.	,, 15.	74½	— 0	
6.	July 21.	72½	↘ 2	Leaves wet after heavy rains.
7.	Aug. 5.	72	↘ ½	After a wet fortnight following long and severe drought.
8.	Sept. 1.	70½	↘ 1½	
9.	Oct. 17.	75	↗ 4½	Leaves and fruit both falling.
10.	,, 27.	79	↗ 4	After sharp frost; leaves mostly fallen.
11.	Nov. 12.	79	— 0	All leaves fallen.
12.	Dec. 8.	78 (?)	↘ 1 (?)	Observation probably unreliable through error.
	1896.			
13.	April 19.	77	↘ 1	Leaves just coming out.
14.	May 15.	73	↘ 4	After long and severe drought. Foliage perhaps unusually light in consequence.
15.	,, 28.	73	— 0	
16.	June 7.	73	— 0	After several wet days, ending long drought.
17.	Aug. 4.	72	↘ 1	Leaves wet through rain; fruit about half-grown.
18.	Sept. 6.	70	↘ 2	After a wet fortnight; fruit almost fully grown.
19.	,, 28.	68½	↘ 1½	After wet and stormy period; fruit fully grown.
20.	Oct. 25.	74	↗ 5½	All fruit and about half the leaves fallen.
21.	Nov. 29.	76½	↗ 2½	Leaves all fallen.
	1897.			
22.	Mar. 27.	77	↗ ½	Leaf-buds just bursting.
23.	May 2.	73½	↘ 3½	Leaves about half-grown.
24.	,, 15.	72	↘ 1½	Leaves and flowers both almost fully out.
25.	,, 29.	71¼	↘ ¾	Leaves and flowers both fully out.
26.	June 12.	70¾	↘ ½	Fruit beginning to swell.
27.	July 18.	71¾	↗ 1	This slight rise, continuing over a month, in spite of the steady growth of the fruit, and followed by a slight fall, both contrary to all previous observations, were due to special causes, as explained in the body of the paper.
28.	,, 29.	71	↗ ¾	
29.	Aug. 15.	71	— 0	
30.	Sept. 19.	70¾	↘ ¼	Fruit ripening.
31.	Oct. 10.	71½	↗ ¾	Fruit all fallen; leaves falling.
32.	,, 17.	72¾	↗ 1¼	Many leaves fallen.
33.	,, 24.	74½	↗ 1¾	About half of leaves fallen.
34.	,, 31.	75¾	↗ 1¼	Nearly all of leaves fallen.
35.	Nov. 14.	76	↗ ¼	All leaves fallen.
	1898.			
36.	Jan. 9.	75½	↘ ½	
37.	Feb. 6.	75½	— 0	
38.	Mar. 5.	75½	— 0	
39.	,, 27.	75¼	↘ ¼	
40.	April 8.	75¾	↗ ½	Slight rise unaccountable.
41.	,, 16.	75½	↘ ¼	Leaves just coming out.
42.	,, 23.	75	↘ ½	Leaves fast coming out.

The same results are shown diagrammatically in Table B by means of a Chart (Plate 27), which indicates graphically the salient points brought out by my observations.

In regard to this latter table, it may be pointed out that the various gradients in the connecting line do not represent the *actual*, but only the *approximate*, rapidity in the rise and fall of the branch; for my observations were taken at irregular periods and no attempt has been made to indicate on the chart the respective intervals between each. It would be necessary to attempt something of this kind if it were desired that the gradients should represent anything like the *actual* rapidity in the rise and fall of the branch; but, if this were done, the table would be rendered inconveniently wide.

Taking the two foregoing tables together, it will be found upon examination that the results of the observations taken in the three years named accord tolerably well with one another (though interfered with through a special cause in the year 1897), and that these results are very much what one would naturally have expected.

The observations seem to show that the following movements take place:—

During the mid-winter months very little change in the elevation of the branch is observable, as shown by the observations numbered 11, 12, 21, 22, 34, 36, 37, and 38. This period of quiescence may be spoken of as the Winter Rest.

About the middle of April, coincident with the growth of the leaves, a rapid fall commences; and this continues until about the middle of May, when the leaves are almost or quite fully grown and the flowers are out. This Vernal Descent of the branch (as it may be called) is shown by observations 2, 3, 13, 14, 23, 24, 25, 41, and 42.

After this comes a short period during which the descent either ceases or becomes very slight. This may be called the Period of Midsummer Rest. Its existence is indicated by observations 4, 5, 15, 16, and 26.

Later in the summer, beginning early in August and continuing during September, the descent commences again and continues more rapidly than before. This downward movement (the existence of which is shown by observations 6, 7, 8, 17, 18, 19, 29, and 30) may be called the Autumnal Descent, and is due, without doubt, to the development of the fruit.

Finally, the simultaneous fall of both leaves and fruit during October is accompanied by an ascent of the branch—the Autumnal Rise, one may call it—which is both greater and more rapid than any other change in elevation, either ascent or descent, which takes place in the course of the entire year, the branch recovering, during about four weeks (as may be seen in the results of observations 9, 10, 20, 21, 31, 32, 33, and 34), the elevation it has been more or less rapidly losing during the preceding twenty-five weeks or thereabout. Upon this Autumnal Rise succeeds the Winter Rest, already spoken of.

A disturbing cause (alluded to above) is apparent in connection with the observations numbered 27, 28, 29, and 30, made on and between July 18th and September 19th 1897, respectively. During this period, not only did the usual rapid autumn descent not take place, but there was first a slight fall, then a period of no change, and, finally, a very slight rise; all which movements are in striking contrast to what took place at the same periods during the two preceding years. This was due, perhaps, in part to the very hot dry weather which prevailed during June, and led, doubtless, to the foliage being less luxuriant (and therefore lighter) than usual; but it was certainly due, in the main, to the great injury done to the foliage and young fruit by the astounding hailstorm and 'tornado' which devastated the central part of Essex on June 24th. Although my house stands on the extreme margin of the storm-area, and although the hailstones which fell around it were of very small size compared with those which fell only a mile away, the injury to growing crops and vegetation of all kinds was exceedingly great, and about sixty panes of glass were smashed in my house and greenhouse. The leaves of the chestnut-tree in question were very severely cut and slashed and pierced, so that their weight upon the branch must have been very substantially less than before the storm. I have shown on the Chart, by means of a broken line, the course the connecting line would probably have taken had it not been for this drought and extraordinary hailstorm.

My observations, as shown on the Chart (Table B., Pl. 27.), seem also to bring out another point in connection with the rise and fall of the branch—namely, that (in addition to its *periodic seasonal rise and fall*, as described above) it is also gradually undergoing a *permanent descent*; for both its maximum and minimum elevations showed a tendency to lessen in each succeeding

year. Thus, as regards its greatest elevation in each year, this was:—

In 1895, 81 inches;
„ 1896, 77 inches;
„ 1897, the same; and,
„ 1898, $75\frac{3}{4}$ inches.

Again, as regards the minimum elevation (or greatest depression) in each year, this was:—

In 1895, $70\frac{1}{2}$ inches;
„ 1896, $68\frac{1}{2}$ inches; and
„ 1897, $70\frac{3}{4}$ inches.

If it had not been for the great hailstorm, it would probably have been about 67 inches, instead of $70\frac{3}{4}$ inches, in the last-named year.

The extreme range of variation in the elevation of the branch observed during the three years in question was (as will be seen) $12\frac{1}{2}$ inches—from the maximum (81 inches) on April 21st, 1895, to the minimum ($68\frac{1}{2}$ inches) on September 28th, 1896. It appears probable, however, that a still lower minimum would have been observed in the autumn of 1897 but for the effects of the great hailstorm.

I do not venture to claim for these observations any special or definite value, such as would make them obviously worth recording; but, as one very seldom can foresee exactly how, when, or to whom any such series of observations may prove useful, I am not without hope that my observations may, in some unexpected way, prove valuable to some future observer.

Nor need I point out that many more observations on other trees require to be made before we are able to state that such movements as those undergone by the branch of this chestnut-tree are usual and ordinary.

EXPLANATION OF PLATE 27.

Seasonal Chart showing approximately the variations in rise and fall of branch of *Æsculus Hippocastanum*.

TABLE B.

SEASONAL VARIATION IN HORSE CHESTNUT

Mintern Bros. lith.

On the Fruit of *Chnoospora fastigiata*, J. Ag. By ETHEL SARA BARTON. (Communicated by GEORGE MURRAY, F.R.S., F.L.S.)

[Read 30th June, 1898.]

(PLATE 28.)

THE genus *Chnoospora* was founded by Prof. J. G. Agardh on the two species *C. pacifica* and *C. atlantica* in "Nya Alger från Mexico" (Öfversigt K. Vet.-Akad. Förhandl., Årg. iv., 1847, p. 7), where the fruit is described "an in verrucis lateralibus, e cellulis radiantibus constitutis, demum evoluti? Genus Sporochnoideum, *Carpomitræ* proximum."

A year later the same author unites *C. pacifica* and *C. atlantica* under the name *C. fastigiata*, and the fruits are described with more detail (Spec. Gen. et Ord. Fucoid. 1848, p. 171). They are said to consist of "sporiferous threads" growing in patches in the centre of the thallus, surrounded and protected by "a series of branched, long-jointed sterile threads." These "sterile threads" are also said to be coherent and covered by a cuticle, in specimens which have been dried and moistened again. An analogy is drawn between this form of fruiting tissue and that of *Arthrocladia*, and *Chnoospora* is placed next to that genus in *Sporochnoideæ*. *Dictyota* and *Carpomitra* are also mentioned as bearing a superficial resemblance to *Chnoospora*.

Dr. Kjellman (Engler and Prantl, Natürl. Pflanzenfam. Teil i. Abt. 2, p. 289) places *Chnoospora* among the genera of *Phæophyceæ* which are "doubtful, uncertain, or insufficiently known;" and Dr. de Toni (Syll. Algarum, vol. iii. Fucoideæ, 1895, p. 464) leaves it as a "genus incertæ sedis" next to *Arthrocladia* in *Arthrocladiaceæ*.

In the British Museum Herbarium *Chnoospora fastigiata* is well represented both in dried and in spirit material. Some good specimens of the plant were sent over in spirit by Mr. Elliot from St. Vincent, in a collection of algæ made by him in the West Indies in 1892. Examination soon showed the presence of cryptostomata growing on the flattened part of the slightly compressed thallus, resembling those which are found in *Soranthera*, *Hydroclathrus*, and *Colpomenia*. The finding of these bodies, where they had hitherto been unsuspected, raised the hope of throwing some light on the development of the fruit and the true position of the genus. A series of sections was

therefore made through a young part of the thallus, with the result that the cryptostomata were found to form the centre of sori of plurilocular sporangia, as known in *Colpomenia.* The sporangia develop centrifugally and apparently coalesce, so that long patches of fruiting tissue are formed up the centre of the thallus, the most protected part of the plant.

The tufts of hairs arising from the cryptostomata are probably the hairs described by Prof. Agardh as being directly connected with the fruit; the "sterile" portion surrounding the "sporiferous threads," which is covered by a cuticle, being perhaps the sorus of plurilocular sporangia. It is not easy, however, to see what is meant by the "branched sterile hairs," which could only refer again to the cryptostoma hairs, and is even then not an accurate description. The only explanation of the "sporiferous threads" that I can suggest is that sometimes a few of the hairs in the cryptostomata are broken off short at the growing point and are very full of contents; their upper cells are more or less rounded, and these may be the "spore-bearing threads" of Prof. Agardh, while the long hairs are those which are said to act protectively and are likened to those in *Arthrocladia.*

The finding of cryptostomata surrounded by plurilocular sporangia makes it now possible to speak definitely with regard to the systematic position of *Chnoospora.* All resemblance between it and *Arthrocladia* is at an end, and the nearest allies of the genus must be sought among *Encœliaceæ.* The present limits of this Order, as generally accepted, will not entirely hold good, as has been shown in the life-history of *Soranthera ulvoidea,* Post. et Rupr.; but for the present, in any case, *Chnoospora* must take its place in *Encœliaceæ* next to *Hydroclathrus* and *Colpomenia.*

An examination of the material of *Chnoospora fastigiata* collected by Dr. Harvey in Ceylon also shows distinct cryptostomata in the centre of the plurilocular sporangia.

EXPLANATION OF PLATE 28.

Fig. 1. *Chnoospora fastigiata.* Small plant. Nat. size.
2. Transverse section of thallus, showing cryptostoma and sorus. ×45.
3. Cortical cells of same. × 450.
4. Cryptostoma and plurilocular sporangia. × 375.
5. Mature and empty sporangia. × 375.

F Higley del et lith.

INDEX.

[Synonyms and native names are printed in *italics*. A star is added to names which are ostensibly here published for the first time.]

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